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INDUSTRIAL WASTE SURVEY REPORT. BETHLEHEM STEEL COMPANY, LACKAWANNA, NEW YORK: AUGUST 9 TO SEPTEMBER 30, 1948; DECEMBER 7, 1949 TO JANUARY 17, 1950; OCTOBER 16, 1951 TO NOVEMBER 15, 1951

Environmental Health Center
Cincinnati, Ohio

15 November 1951

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Industrial Waste Survey Report

BETHLEHEM STEEL COMPANY

LACKAWANNA, NEW YORK

August 9 to September 30, 1949
December 7, 1949, to January 17, 1950
October 16, 1951, to November 15, 1951

A STUDY OF THE CHARACTERISTICS OF LIQUID WASTES FROM AN INTEGRATED STEEL MILL

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Lackawanna, New York

ABSTRACT

This study of process wastes from the Lackawanna Plant of the Bethlehem Steel Company was undertaken as part of the Public Health Service program of industrial waste studies. Three major waste sources of this integrated steel mill and outfall discharges of the entire plant were surveyed. Summaries of each of these studies ~~appear below~~ are included.

Blast Furnace Wastes

Wastes from five operating blast furnaces were checked for the period of August 9 to 19, 1949. Process wastes from blast furnace operation emanate from the cleaning of gas prior to its combustion in various plant facilities. Primary wet washers were of a countercurrent tower type: the removal of fine dust particles being based on the intimate mixing of the gas with water. Secondary gas washers were of the electrical precipitator type, with tubes continually flushed with water.

Samples were collected hourly over an 8-hour period, and composited. Flow to each unit was obtained from registering meters and checked by integrating flow charts. Analyses included the various solids determinations and total iron.

Pertinent data summarizing this survey are tabulated below.

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Summary data for the gas washer wastes are tabulated below:

Furnace	Unit values - per ton pig iron produced			
	Cooling water 1000 gallons	Cooling water recirculated to wet washer 1000 gallons	Suspended solids pounds	Iron as Fe pounds
A	6.1	4.3	49.6	19.8
B	6.1	2.6	36.0	13.8
C	5.9	1.5	39.4	15.0
G	6.2	3.2	52.3	20.7
H	3.9	2.3	34.1	10.8

Summary data for the electrical precipitator wastes are shown below:

Precipitator unit	Unit values - per million cu.ft. gas cleaned		
	Water flow 1000 gals.	Suspended solids added pounds	Iron as Fe added pounds
1 and 2	29.2	8.5	0.92
3 and 4	12.5	8.6	1.12

At design gas flow, the water usage is 5500 gallons per million cubic feet of gas cleaned. Neither precipitator unit was operating at capacity during this study.

By-Product Coke Plant Wastes

This by-product coke plant operates 383 ovens, producing coke for use in the blast furnaces, gas which is used as fuel in various plant operations, and other by-products. An average of 8298 tons of coal were carbonized daily at the plant, producing approximately 5815 tons of coke and 84 million cubic feet of gas. Treatment of the gas for recovery of by-products yielded the following average daily quantities: ammonium sulfate 150,000 pounds, tar 51,256 gallons, light oil 25,821 gallons, sodium phenolate 416 gallons.

In addition to by-product recovery processes proper, facilities are provided for refining the light oil recovered from the gas, the oil being separated into its component fractions of forerunnings, benzol, toluol, xylol, crude solvent naphtha and residue. This refining, together with light oil recovery, is carried out in a specially protected area designated as the "benzol plant."

The wastes of the coke plant were measured, sampled and analyzed during a period from October 16 to November 15, 1951. Of particular importance was the fact that the plant was operating at unusually high coking temperatures during this period, average flue temperature being 2468°F. High temperature operation is known to reduce appreciably the quantity of phenol produced.

Wastes from all coke plant operations except the benzol plant are discharged through the main coke plant drain northward to the ship canal. The benzol plant wastes are discharged to the ship canal near its south end through the benzol plant sewer. Principal component wastes discharged to the main coke plant drain are: (1) ammonia still waste, (2) ammonia liquor cooling water, (3) coke quenching water, (4) gas producer waste, and (5) leaks from the final cooler recirculation system. The benzol plant sewer discharge is made up of cooling water, discharge from an intercepting sump, and relatively minor wastes from caustic washes and rinses of the BTX fraction. Wastes entering the intercepting sump originate principally as condensate in water decanters of the various fractionating units. The average volume of flow, and concentration and net quantity of phenol in each main sewer and component waste, are tabulated below:

	Average flow MGD	Average phenol content ppm	Average phenol discharged lbs.	Average phenol per ton of coal carbonized lbs.
Main coke plant drain	17.3	2.0	288	0.0347
Ammonia still waste	0.167	41.0	57	0.0068
Cooling water ammonia liquor	12.2	0.13	13.2	0.0016
Quench water	1.02	1.46	12.4	0.0015
Gas producer waste	0.64	9.9	52.8	0.0064
Leaks of final cooler water			140	0.0169
				Per 1000 gals. light oil refined
Benzol plant main sewer	5.89	1.8	88.3	3.42
Intercepting sump discharge	0.171	48.6	69.0	2.67

Appreciable quantities of cyanide were also contained in these wastes. The main coke plant drain contained an average of 0.3 ppm, which amounts to 43.2 pounds total, or 0.0052 pounds per ton of coal carbonized. Coke plant wastes are known to exert a considerable biochemical oxygen demand, but this determination was not carried out. Benzol plant wastes contain significant quantities of oil, amounting to 6.1 ppm net average concentration in the benzol plant main sewer discharge.

Continuous Strip Mill Wastes

In this mill, slabs are rolled into strip and/or sheet form, being greatly increased in length and reduced in thickness. Light plate is also produced. The steel is rolled in both the hot and cold states, separate facilities being provided in the hot mill for rolling of hot steel and in the cold mill for rolling of cold steel. Provision is also made for pickling, annealing, and such finishing processes as are required to meet consumer requirements of the finished product.

The survey at this mill took place from December 7 to 30, 1949. Three outlets discharge wastes from the mill: (1) a sewer carrying the intermittent flow - 4600 gallons per dump - from the batch pickler and discharging into a drainage ditch, (2) an 18-inch rubber-lined sewer carrying the waste flow - 0.65 M.G.D. - from the continuous pickler and discharging into Smokes Creek, (3) a 60-inch concrete sewer carrying all other liquid wastes - 11.6 M.G.D. - from the mill and discharging into Smokes Creek.

Analyses of the wastes indicated a daily discharge of 40,900 pounds of iron. The major contributor to this total was the waste from the continuous pickler, 85% being found therein. The batch pickler discharge contained 8% of the total, while the scale pit contributed 7%.

The total amount of 5-day B.O.D. discharged in the main outfall was 4180 pounds per day, of which 2500 pounds, or 60%, came from the tandem mill sump.

There were 1080 gallons of oil discharged daily from the main outfall. Most of this oil - 680 gallons, or 63% - was contained in the effluent from the tandem mill sump, while 79 gallons were in that portion of the scale pit effluent which was discharged into the main outfall.

Outfall Sewer Discharges and Water Supply System

Outfall sewer discharges of the entire integrated steel plant were measured, sampled and analyzed during the period of October 16 through October 24, 1951. Samples were also taken of the water supplies, to arrive at net results.

The Lackawanna plant of the Bethlehem Steel Company uses approximately 213 million gallons of water daily. Water for process and cooling purposes is pumped from three stations, designated numbers 1, 2, and 10. Station No. 2 pumps approximately 60 M.G.D. from Buffalo Harbor itself, mainly to the blast furnace and rolling mills. Stations 1 and 10 draw water from the ship canal which connects with Buffalo Harbor. No. 1 pumps about 130 M.G.D. to the blast furnace and rolling mills, and No. 10 pumps 20 M.G.D. to the coke plant. The Western New York Water Company supplies about 2.8 M.G.D. of treated Lake Erie water which is used principally for sanitary purposes.

The process wastes are discharged to Buffalo Harbor and Lake Erie through three main sewer systems, namely the South drain (18.3 M.G.D.) and Smokes Creek (61.7 M.G.D.), both of which discharge directly to Lake Erie, and the drain north to Buffalo Harbor (107 M.G.D.) which empties into Union Ship Canal before reaching Buffalo Harbor. All of the coke plant wastes (approximately 23 M.G.D.) flow directly into the company ship canal, from which about 150 M.G.D. of water are pumped by water supply stations numbers 10 and 1. Knowing that 127 M.G.D. of water must flow into the ship canal, it may be assumed that the coke plant wastes leave the ship canal through pump station number 1.

The average gross concentrations and quantities of significant waste constituents discharged from the three plant outfalls are as follows:

Concentrations	Drain north to Buffalo Harbor	Smokes Creek	South Drain	
Phenols, ppm	0.13	0.18	0.12	
Cyanides (as CN), ppm	<0.10	0.17	<0.10	
Suspended solids, ppm	53	143	61	
pH range	7.0 - 7.6	3.8-6.0	3.0-5.5	
Flow, mgd	107	61.7	18.3	
Quantities				Total
Phenols, lbs	117	94	18.5	230
Cyanides (as CN), lbs	81	86	5.9	173
Suspended solids, lbs	47,100	72,900	9030	129,030

In considering the suspended solids in Smokes Creek, attention is called to the fact that the settling unit for the wastes of one blast furnace was temporarily out of operation during this survey. This untreated gas washing water was discharged to Smokes Creek.

Arriving at figures for net quantities discharged is quite involved. One complicating factor is that wastes discharged through the North outfall to Buffalo Harbor are likely to be contained in part in the water flowing into the ship canal and ultimately entering the pumping stations. A second factor is the discharge of coke plant wastes to the ship canal. Assuming the quality of the water pumped from station number 2 as being representative of the water entering the ship canal, the following net quantities of waste constituents are obtained:

Phenols	157 pounds
Cyanides (as CN)	173 "
Suspended solids	116,400 "

Results obtained on the quantity of phenols and cyanides discharged to the ship canal in coke plant wastes and the quantitities contained in water pumped from the ship canal by station number 1 showed considerable reductions in the canal. Neglecting the phenol content of waters entering the ship canal, the following reductions are indicated:

	Phenols Pounds	Cyanide (as CN) Pounds
Gross quantity in coke plant wastes	401	72
Quantities pumped by Pump station No. 1	162	0
Reduction in ship canal	239	72

GENERAL INFORMATION SECTION

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GENERAL INFORMATION

Organization of Survey

Representatives of Bethlehem Steel Company, New York State Department of Health, and Public Health Service, met on July 7, 1949, for a conference at the Lackawanna Plant offices of the Bethlehem Steel Co. The object of the conference was to discuss and outline proposed studies of major wastes produced in the operation of the Lackawanna Steel Plant.

Subsequent correspondence between Bethlehem Steel Co. and the Public Health Service confirmed the tentative plans discussed at this conference and arranged for the arrival of a Public Health Service field unit for this survey.

Purpose of Survey

This survey was conducted to obtain detailed information regarding principal process wastes resulting from the operation of an integrated steel plant. Three major waste sources were studied during the survey, namely:

1. Blast furnaces
2. By-product coke plant
3. Continuous strip mill

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Personnel Participating

Bethlehem Steel Company

P. F. Kinyoun, Combustion Engineer

John B. Hill, Superintendent, Blast Furnaces

Robert W. Pugh, Superintendent, Coke Plant

J. A. Joseph, Engineer, Combustion Engineering Department

T. Tooke, Engineer, Strip Mill Division

W. N. Cottet, General Foreman, Main Chemical Laboratory

Public Health Service

Hayse H. Black, Chief, Industrial Waste Section

Charles E. Sponagle, Asst. Sanitary Engineer

John R. Thoman, Sanitary Engineer

Stanley G. Monroe, Senior Sanitary Engineer (R)

Gerald N. McDermott, S. A. Sanitary Engineer

Donald A. Pecsok, Asst. Sanitary Engineer

Dean M. Taylor, Public Health Engineer

William W. Walker, Sanitary Chemist

Carl N. Shadix, Sanitary Chemist

Carl R. Hirth, Physical Science Aide

S. D. Pinkoski, Physical Science Aide

Paul F. Jones, Engineering Aide

Melvin D. Currey, Automotive Mechanic

Dates of Survey

The survey commenced on August 9, 1949, and from this date until September 30, 1949, samples of the blast furnace wastes were collected and analyzed. A strike of steelworkers then necessitated suspension of the survey. The field unit returned to the plant following settlement of the strike, and a study of the wastes from the continuous strip mill was begun on December 7, 1949. Coke plant wastes and outfall waste discharges of the plant were studied between October 16 and November 15, 1951.

Plant Operations

Operations of the blast furnaces, open-hearth furnaces, and by-product coke plant, are continuous. Operation of the various mills is on an "as required" basis. The plant operates on an 8-hour shift basis, with the day shift starting at 7:00 A.M. Employees work a 40-hour week.

Location of Plant

The Lackawanna plant of the Bethlehem Steel Company is located in the city of Lackawanna, New York, on the shores of Lake Erie. The plant covers an area of 1626 acres, of which 1327 acres are in use, reserve plant land and property in the immediate area amounting to 299 acres.

Employees

The number of employees in the period between the 1949 and 1951 phases of this survey increased considerably; therefore, figures for both periods are given.

1949 period - Employees of the Lackawanna plant total approximately 14,500. Considering continuous operations, for certain departments, the maximum number of employees on duty during any one 24-hour period will normally not exceed 12,000. Breakdown by shift is as follows: day shift 5,500, second shift 3,000, third shift 3,000.

1951 period - Employees of the Lackawanna plant total approximately 16,000. Considering continuous operations for certain departments and the five-day work week, the number of employees on duty during any one 24-hour shift will normally not exceed 12,670. Breakdown by shift is as follows: day shift 6,300, second shift 3,200, third shift 3,200.

Raw Materials

Principal raw materials used are iron ore, coke, limestone, sulfuric acid, and lime. Iron ore used is hematite, 50% Fe, from the Mesabi Range, Minnesota. Pennsylvania and West Virginia coals are ordinarily used for coking. Limestone is obtained from quarries in Michigan.

Production

During the studies of the blast furnace wastes and the rolling mill wastes in 1949, six blast furnaces produced about 180,000 tons of pig iron per month. Blast furnace gas production was about 20 million cubic feet of gas per hour. Open-hearth steel production averaged 275,000 tons per month from a total of 30 furnaces.

During the studies of the outfall waste line discharges of the entire plant in 1951, the six blast furnaces produced about

215,000 tons per month of pig iron. Open-hearth steel production averaged about 320,000 tons per month. The coke plant in the 1951 period carbonized about 252,000 tons per month of coal, and produced about 180,000 tons of coke per month, 83 million cubic feet of gas per day, and other by-products.

Water Supply

Process water for the plant is obtained from three pumping stations. No. 1 pump station draws from the ship canal, at a point 3000 feet from the canal's junction with Buffalo Harbor. No. 10 pump station also pumps water from the ship canal at a point practically directly across the canal from No. 1 station. No. 2 pump station draws water from Buffalo Harbor itself, at a point near the mouth of the ship canal.

Boiler feed water is filtered and softened by lime-soda process, while other water is used without treatment.

A relatively minor quantity of treated Lake Erie water is purchased from the Western New York Water Company which also supplies water to local municipalities. This water is used for sanitary purposes in all of the plant buildings.

Details of quantities pumped are found in Section D, "Outfall Sewer Discharges and Water Supply System." Reference is made to the map in that section.

Sewers

Process and sanitary wastes from the plant are discharged through several outlets. Two outlets discharge direct to Lake Erie proper. These two are Smokes Creek and the drainage ditch, known as South Drain, with outlet immediately west of Western New York Water Company water purification plant. A third drain discharges to Union Canal near its junction with Buffalo Harbor. The wastes of the coke plant are discharged to Bethlehem Steel Company's own ship canal. Since much of the steel mill's water supply is drawn from the ship canal in quantities several times the volume of coke plant wastes discharged to it, it would be expected that flows were generally into the ship canal from the Harbor. Thus the coke plant wastes are considered to become part of the water supply of other processes and are thus ultimately discharged through the two outlets direct to Lake Erie and the outlet to Union Canal.

Details of quantities discharged through each outlet are found in Section D, "Outfall Sewer Discharges and Water Supply System." Reference is made to the map in that section.

A portion of the sanitary wastes receive septic tank treatment. Septic tank effluent and untreated sanitary wastes discharge to the mill sewer system.

SECTION A

BLAST FURNACE WASTES

August 9-19, 1949

By

Charles E. Sponagle, Asst. Sanitary Engineer
John R. Thoman, Sanitary Engineer

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SECTION A

Blast Furnace Waste

Pig iron produced by this department is used in the manufacture of steel and steel products by the Lackawanna plant. Pig iron, as such, is cast at infrequent intervals. Liquid process wastes in blast furnace operations come from the cleansing of the gas prior to use in plant facilities. The process of pig iron manufacture is described briefly. Procedures used and results of the survey follow. A flow diagram of pig iron manufacture is shown in Figure A-1.

Description of Process

Blast Furnaces

This plant is equipped with six blast furnaces and auxiliary equipment. The installation dates and normal capacities of these furnaces are shown in the following table:

1918 (2 furnaces)	750 tons per day each
1929	1000 tons per day
1936	1100 "
1941	1200 "
1943	1200 "

Each furnace is equipped with its own auxiliary equipment consisting of stoves, dry-dust catchers, and wet washers. Centralized stations furnish water and air to each furnace. Electrostatic precipitators are located at two points for removing dust from the gas prior to use in steam generating power plants.

Ore, limestone, coke, and open-hearth slag, are charged into the top of the furnace. Preheated air is blown into the furnace through openings (tuyeres) located near the bottom of the furnace. Slag and molten pig iron are drawn off the bottom of the furnace; the cinder notch being slightly above the tap hole for iron. Casts are made five times daily. With normal operation, the casts occur at approximately the same time each day.

Stoves

Each blast furnace is equipped with four stoves for furnishing the hot blast. Only one stove is on "blast" at any one time, the remaining ones in service being heated. These stoves are equipped with an intricate checkerwork of refractory materials for retaining the heat supplied. Cleaned blast furnace gas is used as fuel in these stoves.

Dry-Dust Catcher

The gas collected at the top of each blast furnace is led through downcomers to a dry-dust catcher. This equipment is of the inertial or cyclone type. Dry dust is removed periodically through an air lock, to a gondola car.

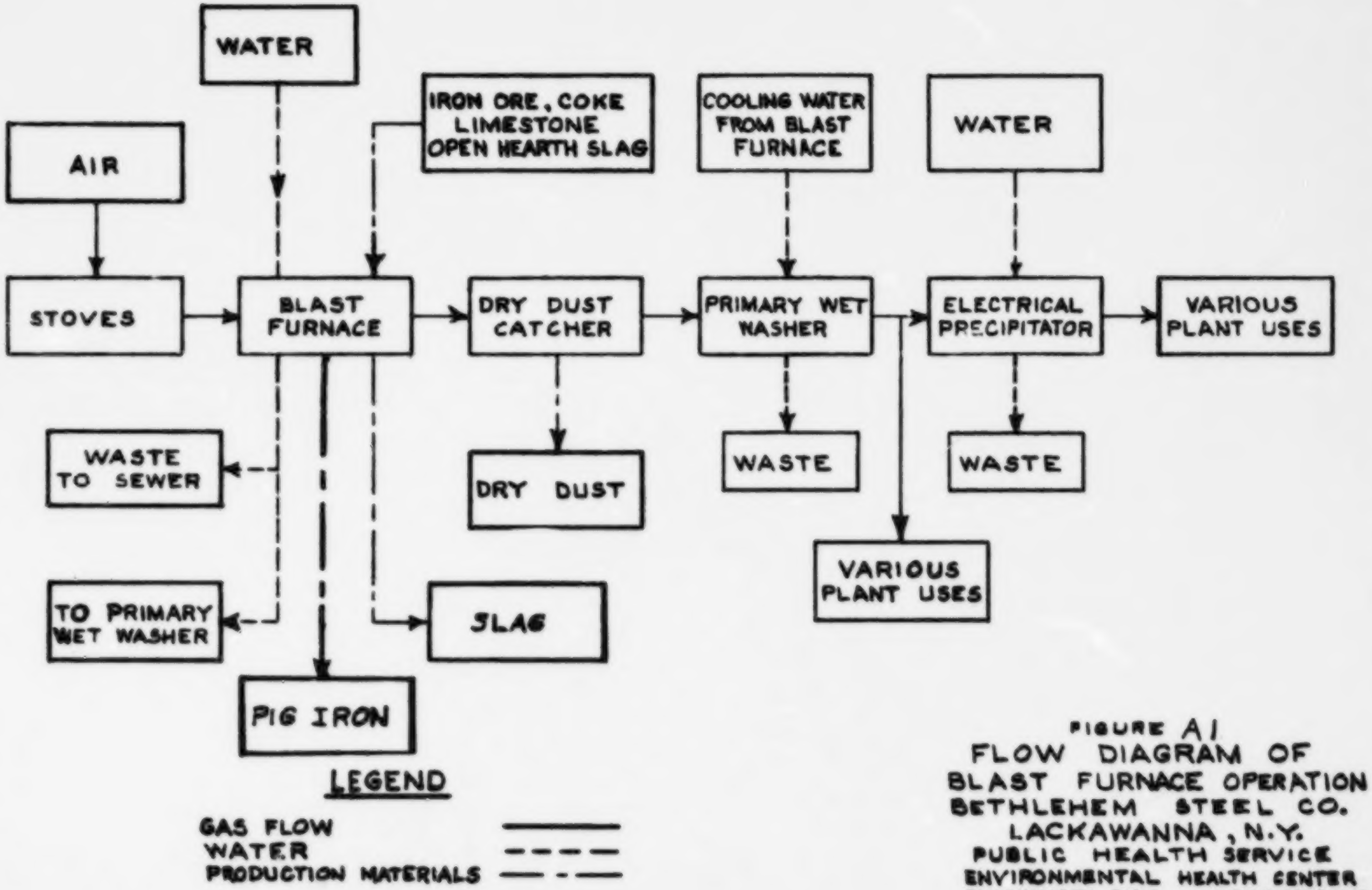
WATER
AIR
IRON ORE, COKE LIMESTONE OPEN HEARTH SLAG
COOLING WATER FROM BLAST FURNACE
WATER
STOVES
BLAST FURNACE
DRY DUST CATCHER
PRIMARY WET WASHER
ELECTRICAL PRECIPITATOR
VARIOUS PLANT USES
WASTE TO SEWER
DRY DUST
WASTE
WASTE
VARIOUS PLANT USES
TO PRIMARY WET WASHER
SLAG
PIG IRON
LEGEND
GAS FLOW
WATER
PRODUCTION MATERIALS

FIGURE A1
FLOW DIAGRAM OF
BLAST FURNACE OPERATION
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1959

Primary Wet Washers

The function of wet washing of the blast furnace gas is to remove the finer particles of material not settling out in the dry-dust catcher. The principle involved is to bring the gas into intimate contact with water in countercurrent-type towers. Two general kinds are used at the Lackawanna plant. They are the Feld and the Pease-Anthony types. Descriptions of these washers, together with diagrammatic sketches, are given.

(a) Feld Type - The gas enters the bottom of the washer and passes upward through a series of perforated plates. Water enters the top of the washer through sprays. In each section, it is collected in truncated cone holders mounted on a revolving center shaft. By centrifugal force it is thrown out over the perforated plates falling to the next collection cone. This procedure is repeated several times in the washer. Some units have been modified by the addition of jet sprays near the conical bottom of the washer. A sketch of this type unit is shown in Figure A-2.

(b) Pease-Anthony Type - The gas enters this unit tangentially at the bottom. In the lower section the gas continues to move with a circular motion. Jet nozzle sprays mounted on a central supply pipe spray water into the gas in this section. The gas then passes through a section equipped with straightening vanes to direct and spread out the flow before passage through the upper cleaning section. In the upper portion there are several tile grids through which the gas must pass, and over which water trickles from a perforated pipe grid. A diagrammatic sketch of this type unit is shown in Figure A-3.

Electrical Precipitators

The electrical precipitators are of the type manufactured by the Research Corporation. Gas enters at the side of the unit, passes down around the tubes, then up through the tubes to the outlet. The tubes comprise the collecting electrodes. Water flows over these tubes in a fine film. Water is introduced at the top header plate. At the top of each tube is a weir ring to regulate the water discharge. Parts of the precipitator not ordinarily receiving water are flushed through special nozzles several times a day. A sketch of this type unit is shown in Figure A-4.

Survey Procedures

Sample Collection

Samples were collected from the wet washer discharge pipe at each of the five blast furnaces operating. In ordinary practice, this waste entered a gondola car for settling. The samples were taken before settling. At H furnace, two discharge pipes were in use, and these sources were used alternately throughout the sampling period.

Samples of the electrical precipitator wastes were collected from the discharge pipes. Two such pipes were in use at each unit, and samples were alternated.

Raw water entering the electrical precipitators was taken from sampling cocks located in the regulator box at each unit.

Composite samples of equal portions were collected each 60 minutes from 8:00 A.M. to 4:00 P.M., except for August 9 when they

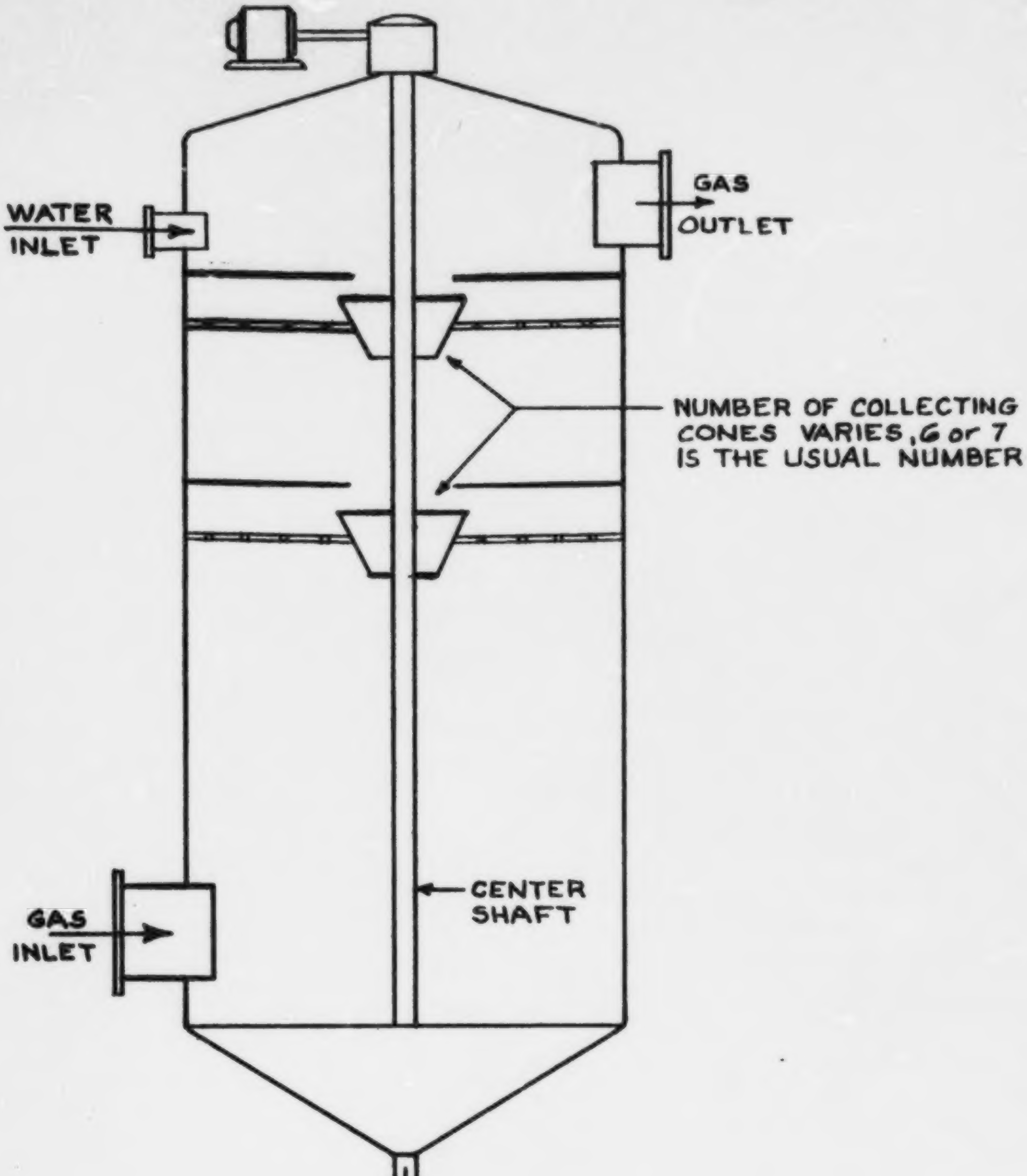
WATER INLET
GAS OUTLET
NUMBER OF COLLECTING CONES VARIES, 6 or 7 IS THE USUAL NUMBER
CENTER SHAFT
GAS INLET
WATER OUTLET

FIGURE A2
SCHEMATIC DRAWING
FELD TYPE PRIMARY GAS WASHER
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

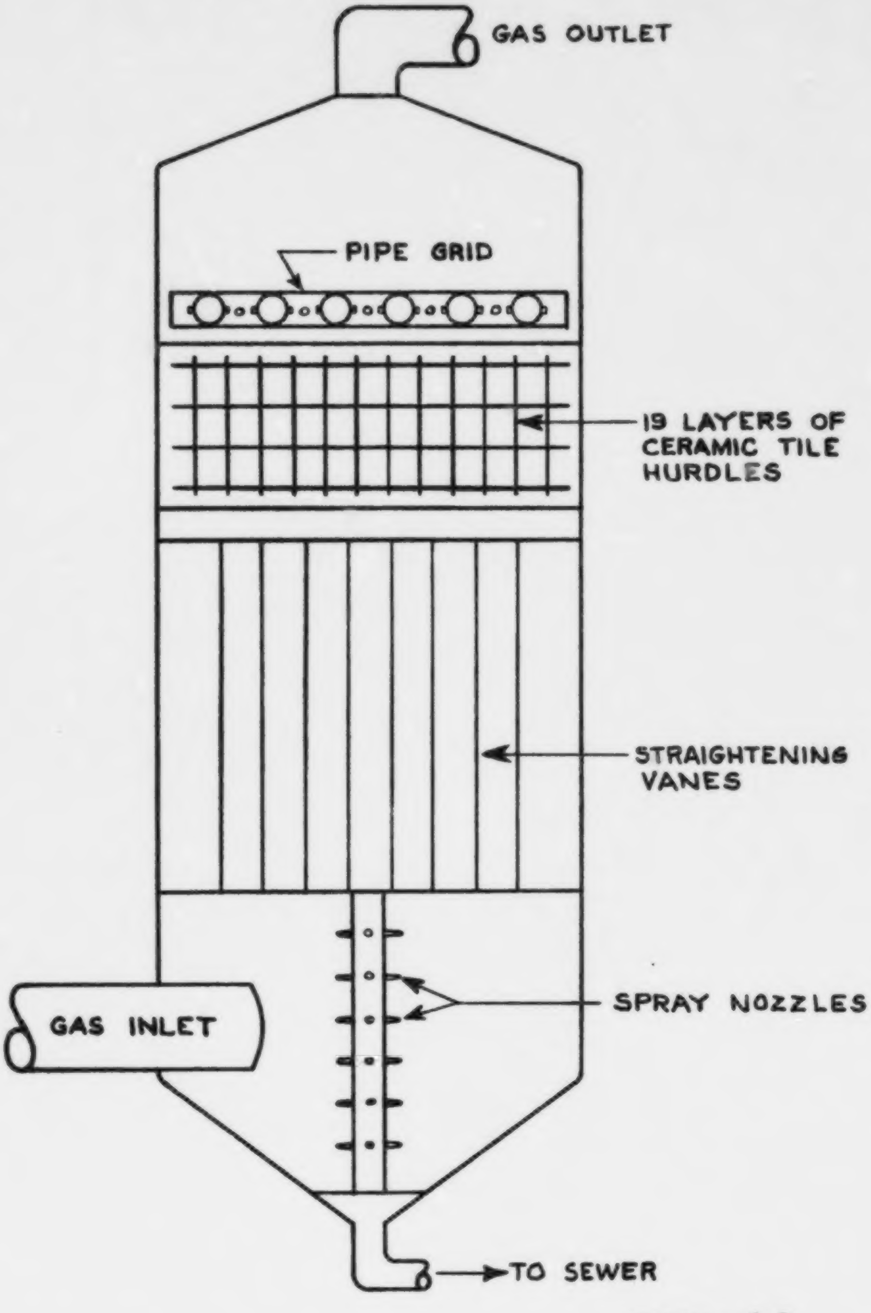
GAS OUTLET
PIPE GRID
19 LAYERS OF CERAMIC TILE HURDLES
STRAIGHTENING VANES
SPRAY NOZZLES
GAS INLET
TO SEWER

FIGURE A3
SCHEMATIC DIAGRAM
PEASE-ANTHONY TYPE GAS WASHER
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

26.C

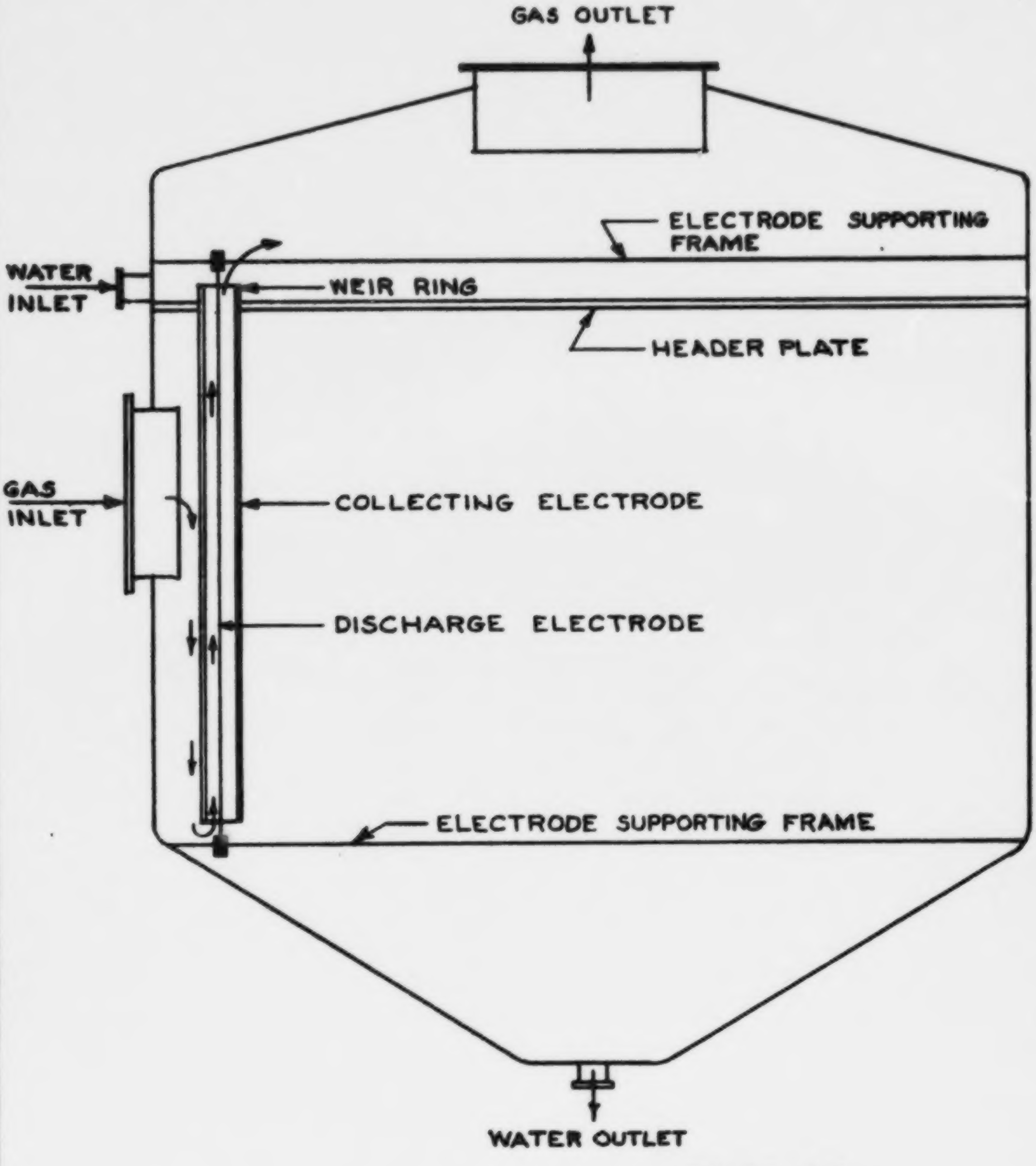
GAS OUTLET
ELECTRODE SUPPORTING FRAME
WATER INLET
WEIR RING
HEADER PLATE
GAS INLET
COLLECTING ELECTRODE
DISCHARGE ELECTRODE
ELECTRODE SUPPORTING FRAME
WATER OUTLET

FIGURE A4
SCHEMATIC DRAWING
RESEARCH CORP. ELECTRICAL PRECIPITATOR
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

were collected at 60-minute intervals. Samples were collected by Bethlehem Steel Company personnel. One composite sample at H furnace was taken at 15-minute intervals for comparison with the 60-minute-frequency sample. Temperatures of the samples were taken once during each sampling period.

Flow Measurements

Flows to the blast furnace for cooling, and of recirculated water to the wet washers at each blast furnace, were furnished by Bethlehem Steel Company from meter records. It was reported that the meter charts were integrated to check the totalizing registers at each meter.

Only indicating meters were available at the electrical precipitators. Eight meters at each unit were read twice daily, at the time of the first and last sampling series. The results were averaged and converted to daily quantities.

Laboratory Procedures

The following determinations were made on the samples collected:

Total iron
Total solids
  Total
  Volatile
Suspended solids
  Total
  Volatile
pH

The procedures followed in making these analyses are, in general, given in "Standard Methods for the Examination of Water and

Sewage," 9th edition.(1) The method used for total iron was furnished by the Bethlehem Steel Company and is given in Appendix B.

Production Data

Data were furnished by the Bethlehem Steel Company, giving all pertinent information concerning the operation of the blast furnaces during the period of the survey. These data are shown in Appendix A. They contain information concerning the charge, air blast, water, and production of pig iron, slag, gas and dry dust recovered.

Explanation of Analyses

The materials for which analyses were made have certain significance to water pollution. Reference is made to the section of the main appendix dealing with explanation of laboratory analyses for a discussion of the determinations in this regard.

Results

During this survey, the blast furnaces (one was not in service) were operating under conditions expected to produce normal volume and strength of wastes. Bethlehem operating personnel stated that observations over a 2-week period would be expected to show normal variations in the wastes. Care was exercised in collecting samples; they were not collected or analysed if the washers were shut down for any portion of the sampling period.

Detailed production, analytical, and quantity data are shown in Appendix A. Summary data are given in this section of the report.

Waste Quantities

Water consumption in the blast furnaces and auxiliary equipment was fairly constant during the period of this survey. Average water consumption at each furnace is shown below. Only those days for which analytical data are available were included to obtain these mean values.

Furnace	Total water to furnace MGD	Recirculated to wet washer MGD	Discharged cooling water MGD
A	5.19	3.62	1.57
B	4.84	2.03	2.81
C	6.31	1.58	4.73
G	6.32	3.24	3.08
H	5.53	3.21	2.32

Unit values of water used for cooling and for wet washing of the gas are tabulated below:

Furnace	Total cooling water 1000 gal. per ton pig iron	Wet washer water	
		1000 gal. per ton pig iron	1000 gal. per million cu.ft. gas
A	6.1	4.3	43.1
B	6.1	2.6	24.3
C	5.9	1.5	12.5
G	6.2	3.2	27.5
H	3.9	2.3	21.4

With the exception of H furnace, approximately 6,000 gallons of water per ton pig iron produced were required for cooling purposes. Less than 4,000 gallons per ton pig iron were used in H furnace.

Cooling water recirculated to the primary wet washers varied considerably among the furnaces. A minimum of 1,500 gallons per ton pig iron was used in the Pease-Anthony type washers of C furnace. The maximum was 4,300 gallons per ton pig iron in the Feld type washer at A furnace. It was stated that the A furnace washer was not operating as well as the others, and this may indicate an extreme water use figure. Of particular significance is the fact that only about one-half as much water per million cubic feet of gas cleaned was required by the Pease-Anthony type washer as compared with the Feld type washers.

Water use in each precipitator installation was 1.58 M.G.D. This flow represents average water use for the installation regardless of the quantity of gas cleaned. Each unit was designed to clean 12 million cubic feet of gas per hour. At the design rate, 5,500 gallons of water per million cubic feet of gas would be required. Observed unit values during this survey are shown below:

Precipitator unit	Wash water 1000 gallons per million cu.ft. gas
1 and 2	29.2
3 and 4	12.5

Waste Characteristics

Average values for the analyses made of the wastes from the gas washers for the five operating blast furnaces are tabulated below:

Furnace	No. of samples	Temp. °C.	pH	Total Solids		Susp. Solids		Iron as Fe
				Total	Volatile	Total	Volatile	
				ppm	ppm	ppm	ppm	ppm
A	8	50	7.1-7.6	1680	272	1390	192	553
B	9	54	7.0-7.9	2060	370	1700	210	651
C	6	57	7.7-8.4	3690	457	3150	262	1260
G	8	58	7.5-7.9	2390	361	1980	240	785
H	9	53	7.2-9.4	2300	502	1810	281	471

Mean values for the total waste quantities from the gas washers for the blast furnaces are shown below:

Furnace	Suspended solids lbs./day	Iron as Fe lbs./day
A	41,900	16,700
B	28,500	11,000
C	42,300	16,100
G	53,100	21,000
H	48,500	15,300

Mean values for the quantities of wastes produced per production unit are listed below:

Furnace	lbs. susp. sol. / ton pig iron	lbs. iron as Fe / ton pig iron	% Fe in susp. solids
A	49.6	19.8	39.9
B	36.0	13.8	38.4
C	39.4	15.0	38.0
G	52.3	20.7	39.5
H	34.1	10.8	31.6

Suspended solids removed from the gas varied from 34.1 pounds per ton pig iron at H furnace to 52.3 pounds at G furnace. Daily variations at each furnace are much more pronounced than this difference. These data show the suspended solids removed in the primary wet washer. They do not relate to the efficiency of the gas washer in removing dust from the gas.

For all practical purposes, no iron in the primary wet washer waste is in solution. Consequently, percentages of iron as Fe in the suspended solids have been computed. This serves to show the per cent recoverable material in the waste and, to some extent, serves as a check on sampling and analytical procedures. This last assumption is based on a more or less common charge being fed to all furnaces. The data show that for furnaces A, B, C, and G, approximately 39% of the suspended solids were iron as Fe. The waste from furnace H showed only 31.6 % of iron in the suspended solids, however. This difference may be due to the particular ore being charged to this furnace at the time of this survey.

In analyzing the data for the wastes from the electrical precipitators, allowance was made for quantities in the raw water. Average total quantities of significant materials in this waste are shown below:

Precipitator unit	Suspended solids added lbs./day	Iron as Fe added lbs./day
1 and 2	444	48
3 and 4	1085	142

Mean quantities per unit of gas cleaned are tabulated below:

Precipitator unit	Lbs. suspended solids added / Million cu.ft. gas	Lbs. iron as Fe added / Million cu.ft.gas	% Iron in suspended solids
1 and 2	8.5	0.92	10.8
3 and 4	8.6	1.12	13.2

The quantity of suspended solids added per unit of gas cleaned was about the same for both units, even though 3 and 4 received over twice as much gas as 1 and 2. Unit 1 and 2 was operated at about 20% of rated capacity, and 3 and 4 at about 50% of capacity during the period of this survey.

SUMMARY

Pertinent data summarizing the results of this survey are shown below:

Summary data for the gas washer wastes are tabulated below:

Furnace	Unit values - per ton of pig iron produced			
	Cooling water 1000 gallons	Cooling water recirculated to wet washer 1000 gallons	Suspended solids pounds	Iron as Fe pounds
A	6.1	4.3	49.6	19.8
B	6.1	2.6	36.0	13.8
C	5.9	1.5	39.4	15.0
G	6.2	3.2	52.3	20.7
H	3.9	2.3	34.1	10.8

Summary data for the electrical precipitator wastes are tabulated below:

Precipitator unit	Unit values - per million cu.ft. gas cleaned		
	Water flow 1000 gallons	Suspended solids added pounds	Iron as Fe added pounds
1 and 2	29.2	8.5	0.92
3 and 4	12.5	8.6	1.12

It should be noted that the precipitators were not operating at design capacity. At design gas flow, unit water use is 5500 gallons per million cubic feet of gas cleaned.

APPENDIX A

BLAST FURNACE DEPARTMENT

Daily Analytical, Waste Quantity and Production Data

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Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949

TABLE A-1 - ANALYTICAL DATA.
PRIMARY GAS WASHER EFFLUENT.

	Date	Sampling Duration Hours	Sampling Frequency Minutes	Temperature °C.	pH	Iron as Fe p.p.m.	Total solids Total p.p.m.	Total solids Volatile p.p.m.	Suspended solids Total p.p.m.	Suspended solids Volatile p.p.m.
Furnace A	August 9	8	80	-	7.6	497	1466	298	1352	260
	10	8	60	51	7.1	243	920	256	532	88
	11	8	60	49	7.3	243	1024	196	676	180
	12	-	-	-	-	-	-	-	-	-
	15	8	60	51	7.6	627	1828	228	1560	204
	16	8	60	49	7.5	970	2504	300	2252	296
	17	8	60	48	7.5	710	2176	332	1780	200
	18	8	60	-	7.1	563	1712	256	1352	108
	19	8	60	-	7.6	571	1832	308	1588	260
	Average	-	-	50	7.1-7.6	553	1683	272	1386	192

Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949

TABLE A-1 - Continued -
ANALYTICAL DATA.
PRIMARY GAS WASHER EFFLUENT.

	Date		Sampling		Temperature °C.	pH	Iron as Fe p.p.m.	Total solids		Suspended solids	
			Duration Hours	Frequency Minutes				Total p.p.m.	Volatile p.p.m.	Total p.p.m.	Volatile p.p.m.
Furnace B	August	9	8	60	-	7.6	1049	2748	384	2604	348
		10	8	60	51	7.0	403	1344	304	964	100
		11	8	60	53.5	7.5	493	1932	412	1828	348
		12	8	60	59	7.9	885	2840	572	2280	324
		15	8	60	56	7.3	1142	3068	364	2440	60
		16	8	60	53	7.3	642	2112	472	1664	224
		17	8	60	54	7.3	198	960	200	628	120
		18	8	60	-	7.1	508	1752	272	1368	136
		19	8	60	-	7.2	542	1788	348	1472	232
	Average		-	-	54	7.0-7.9	651	2060	370	1696	210
Furnace C	August	9	-	-	-	-	-	-	-	-	-
		10	8	60	57	7.7	914	2876	600	2240	368
		11	8	60	56.5	7.9	930	2780	412	2256	276
		12	8	60	57	8.3	1373	4444	296	3676	276
		15	8	60	57	7.9	1588	-	-	-	-
		16	8	60	57	7.9	1297	3888	432	3476	416
		17	8	60	57	8.0	1056	3448	588	2924	436
		18	-	-	-	-	-	-	-	-	-
		19	8	60	-	8.4	1658	4700	416	4352	400
	Average		-	-	57	7.7-8.4	1259	3689	457	3154	262

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Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949

TABLE A-1, Continued -
ANALYTICAL DATA.
PRIMARY GAS WASHER EFFLUENT.

	Date	Sampling		Temperature °C.	pH	Iron as Fe p.p.m.	Total solids		Suspended solids	
		Duration Hours	Frequency Minutes				Total p.p.m.	Volatile p.p.m.	Total p.p.m.	Volatile p.p.m.
Furnace G	August 9	8	80	59	7.7	525	1604	330	1328	168
	10	8.	60	59.5	7.7	549	1988	340	1520	160
	11	8	60	56	7.9	625	2200	352	1696	212
	12	8	60	59	7.9	890	3096	484	2620	280
	15	8	60	60	7.5	1198	2320	220	2040	-
	16	-	-	-	-	-	-	-	-	-
	17	8	60	57	7.7	848	2724	452	2396	364
	18	8	60	-	7.7	969	2876	356	2472	232
	19	8	60	-	7.9	673	2289	352	1796	264
	Average	-	-	58.4	7.5-7.9	785	2387	361	1983	240
Furnace H	August 9	8	80	51	8.0	467	1860	482	1468	328
	10	8	60	50	7.2	547	1640	316	1308	160
	11	8	60	53	8.0	557	2700	548	1832	248
	12	8	60	53	8.1	460	2048	488	1448	208
	15	8	60	54	7.8	408	1828	428	1532	224
	15*	8	15	54	7.8	363	1920	320	1440	204
	16	8	60	53	7.5	367	1828	504	1256	300
	17	8	60	55	7.5	566	2256	580	2096	444
	18	8	60	-	7.5	327	1984	440	1224	192
	19	8	60	-	9.4	1441	4552	736	4084	428
	Average	-	-	52.7	7.2-9.4	571	2299	502	1805	281

* These data not included in mean values.

Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, New York
August, 1949

TABLE A-2 - ANALYTICAL DATA. RAW WATER AND ELECTRICAL PRECIPITATOR EFFLUENT

		Date	Sampling		Temperature °C.	pH	Iron as Fe p.p.m.	Total solids		Suspended solids	
			Duration Hours	Frequency Minutes				Total p.p.m.	Volatile p.p.m.	Total p.p.m.	Volatile p.p.m.
Raw Water	Precipitators 1 and 2	August 9	8	80	28.5	7.6	4.13	206	36	7.5	5.0
		10	8	60	25.5	7.4	3.01	220	102	7.5	5.0
		11	8	60	27.5	7.4	1.68	204	84	9.5	8.5
		12	8	60	26	7.5	2.8	248	102	17	3.5
		15	8	60	26	7.3	1.0	140	76	10	7.5
		16	8	60	23	7.4	1.2	212	80	12	2.0
		17	8	60	27	7.3	1.6	250	118	3.5	2.0
		18	8	60	-	7.5	1.1	232	128	17.5	12.5
		19	8	60	-	7.6	1.4	210	92	6.5	1.0
		Average	-	-	26.2	7.3-7.6	2.0	214	91	10.1	5.2
	Precipitators 3 and 4	August 9	8	80	26.5	8.0	1.90	230	76	7.0	5.0
		10	8	60	29.5	7.2	4.24	270	164	9.5	6.5
		11	8	60	30	7.3	1.12	202	126	9.0	8.5
		12	8	60	29	7.4	1.1	254	104	13.5	2.0
		15	8	60	29	7.2	2.3	226	96	17.5	0.5
		16	8	60	-	7.5	1.3	236	94	14.5	1.5
		17	8	60	32	7.3	0.9	194	110	3.5	2.0
		18	8	60	-	7.3	1.9	228	122	11.5	3.5
		19	8	60	-	7.3	0.9	246	96	9.5	5.5
		Average	-	-	29.3	7.2-8.0	1.7	232	110	10.6	3.9

Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949

TABLE A-2, Continued -
ANALYTICAL DATA. RAW WATER AND ELECTRICAL PRECIPITATOR EFFLUENT

		Date	Sampling Duration Hours	Sampling Frequency Minutes	Temperature °C.	pH	Iron as Fe p.p.m.	Total solids Total p.p.m.	Total solids Volatile p.p.m.	Suspended solids Total p.p.m.	Suspended solids Volatile p.p.m.
Effluent	Precipitators 1 and 2	August 9	8	60	30	7.2	7.48	274	62	42	14
		10	8	60	30	6.6	5.36	312	142	46	[illegible]
		11	8	60	30.5	6.9	3.02	262	114	38	23
		12	8	60	31	7.1	2.3	246	104	49	7
		15	8	60	29	6.7	3.4	214	80	46	13
		16	8	60	28	6.9	4.8	350	148	52	15
		17	8	60	28	6.5	10	372	184	61	9
		18	8	60	-	6.5	4.2	280	140	26	7
		19	8	60	-	6.7	6.0	280	78	34	9
		Average	-	-	29.5	6.5-7.2	5.2	288	106	44	11
	Precipitators 3 and 4	August 9	8	60	34	7.2	18.1	376	94	150	56
		10	8	60	37.5	6.9	11.8	320	140	54	10
		11	8	60	36.5	6.9	6.5	266	92	51	23
		12	8	60	35	7.0	9.2	320	116	76	13
		15	8	60	34	6.9	21.0	388	114	148	4
		16	8	60	36	7.0	21.2	450	172	125	34
		17	-	-	-	-	-	-	-	-	-
		18	8	60	-	6.9	5.6	362	160	92	38
		19	8	60	-	7.0	6.8	372	102	55	17
		Average	-	-	35.5	6.9-7.2	12.5	357	124	94	24

Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949

TABLE A-3 - UNIT VALUES AND QUANTITY OF WASTES
PRIMARY GAS WASHERS

	Date	Pig iron production Tons	Suspended solids		Iron as Fe		% Fe in suspended solids
			Pounds	Pounds per ton pig iron	Pounds	Pounds per ton pig iron	
Furnace A	August 9	798	42,800	53.7	15,700	19.7	36.7
	10	809	16,000	19.8	7,300	9.0	45.6
	11	809	20,300	25.1	7,300	9.0	35.9
	12	-	-	-	-	-	-
	15	848	48,000	56.6	19,300	22.8	40.2
	16	811	69,500	85.7	29,900	36.8	43.0
	17	890	53,400	60.0	21,300	23.9	39.9
	18	881	38,900	44.2	16,200	18.4	41.7
	19	915	46,300	50.6	16,700	18.2	36.1
	Average	845	41,900	49.6	16,700	19.8	39.9
Furnace B	August 9	810	43,400	53.6	17,500	21.6	40.3
	10	766	16,100	21.0	6,750	8.8	41.9
	11	803	30,300	37.7	8,180	10.2	27.0
	12	719	37,100	51.6	14,400	20.0	38.8
	15	850	41,300	48.6	19,300	22.7	46.7
	16	654	28,700	43.9	11,100	17.0	38.7
	17	884	10,700	12.1	3,400	3.9	31.8
	18	809	23,700	29.3	8,700	10.7	36.7
	19	836	25,300	30.3	9,300	11.1	36.8
	Average	792	28,510	36.0	10,960	13.8	38.4

Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949

TABLE A-3, Continued -
UNIT VALUES AND QUANTITY OF WASTES
PRIMARY GAS WASHERS

	Date	Pig iron production Tons	Suspended solids		Iron as Fe		% Fe in suspended solids
			Pounds	Pounds per ton pig iron	Pounds	Pounds per ton pig iron	
Furnace C	August 9	-	-	-	-	-	-
	10	1,175	26,000	22.2	10,600	9.1	40.8
	11	1,020	24,500	24.0	10,100	9.9	41.2
	12	1,078	42,900	39.8	16,000	14.8	37.3
	15	-	-	-	-	-	-
	16	1,099	53,300	48.5	19,900	18.1	37.3
	17	1,067	43,200	40.5	15,600	14.6	36.1
	18	-	-	-	-	-	-
	19	1,001	63,900	63.9	24,300	24.3	38.0
	Average	1,073	42,300	39.4	16,100	15.0	38.0
Furnace G	August 9	1,127	40,200	35.7	15,900	14.1	39.6
	10	1,106	42,600	38.5	15,400	13.9	36.2
	11	1,064	46,800	43.9	17,200	16.2	36.7
	12	1,127	68,000	60.3	23,100	20.5	34.0
	15	882	53,900	61.1	31,600	35.8	58.7
	16	-	-	-	-	-	-
	17	709	65,100	91.8	23,000	32.4	35.3
	18	960	61,200	63.8	24,000	25.0	39.2
	19	1,139	46,600	40.9	17,500	15.4	37.5
	Average	1,014	53,050	52.3	20,960	20.7	39.5
Furnace H	August 9	1,436	38,300	26.7	12,200	8.5	31.8
	10	1,425	35,100	24.6	14,700	10.3	41.8
	11	1,426	49,000	34.4	14,900	10.4	30.4
	12	1,497	39,100	26.1	12,400	8.3	31.7
	15	1,477	42,000	28.4	11,200	7.6	26.7
	16	1,399	32,700	23.4	9,500	6.8	29.1
	17	1,397	56,300	40.3	15,200	10.9	27.0
	18	1,419	32,900	23.2	8,800	6.2	26.7
	19	1,322	111,000	84.0	39,200	29.6	35.3
	Average	1,422	48,490	34.1	15,300	10.8	31.6

TES

n or	I r o n a s F e Iron as Fe Total in precipitator effluent Lb.	 Added by precipitator Lb/MCF Gas	 % Fe in suspended solids added by precipitator
	98.5	0.779	9.7
	70.5	0.512	6.1
	39.8	0.281	4.7
	-	-	-
	44.8	0.715	6.7
	63.3	0.990	9.0
	132.0	2.434	14.7
	55.4	0.741	37.0
	79.0	0.968	16.7
	72.9	0.92	13.8
	238	1.660	11.3
	155	0.777	16.9
	86	0.568	12.9
	121	0.851	12.9
	277	1.915	14.4
	279	2.132	17.9
	-	-	-
	74	0.387	4.6
	90	0.708	14.8
	165	1.12	13.2

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Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949

	Date	Charge			
		Ore Tons	Coke Tons	Limestone Tons	Open-hearth slag Tons
Furnace A	August 9	1,513	660	345	69
	10	1,473	641	338	68
	11	1,338	651	338	68
	12	1,441	641	356	67
	15	1,509	637	346	67
	16	1,709	694	380	73
	17	1,704	713	385	74
	18	1,566	656	347	68
	19	1,626	679	348	71

Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949

TABLE A-4 - UNIT VALUES AND QUANTITY OF WASTES
ELECTRICAL PRECIPITATORS

		Suspended Solids				Iro	
		Gas through precipitator MCF	Total in raw water Lb.	Total in precipitator effluent Lb.	Added by precipitator Lb/MCF Gas	Total in raw water Lb.	Iron as Fe Total in pr effluent
Precipitators 1 and 2	August 9	56.6	99	554	8.0	54.4	98.
	10	60.5	99	606	8.4	39.6	70.
	11	63.0	125	500	6.0	22.1	39.
	12	51.2	224	645	8.2	-	
	15	44.2	132	606	10.7	13.2	44.
	16	48.0	158	685	11.0	15.8	63.
	17	45.6	46	604	16.6	21.1	132.
	18	55.2	231	343	2.0	14.5	55.
	19	62.5	86	448	5.8	18.5	79.
	Average	54.1	133	577	8.5	24.9	72.
Precipitators 3 and 4	August 9	128.3	92	1980	14.7	25.0	238
	10	127.4	125	710	4.6	55.8	155
	11	124.9	119	670	4.4	14.8	86
	12	124.6	178	1000	6.6	14.5	121
	15	129.0	231	1950	13.3	30.3	277
	16	122.9	191	1650	11.9	17.1	279
	17	-	-	-	-	-	-
	18	126.5	152	1210	8.4	25.0	74
	19	124.3	125	725	4.8	11.9	90
	Average	126.0	152	1237	8.6	24.3	165

- UNIT VALUES AND QUANTITY OF WASTES
ELECTRICAL PRECIPITATORS

d Solids			Iron as Fe		
ecipitator Lb.	Added by precipitator Lb/MCF Gas	Total in raw water Lb.	Iron as Fe Total in precipitator effluent Lb.	Added by precipitator Lb/MCF Gas	% Fe in suspended solids added by precipitator
	8.0	54.4	98.5	0.779	9.7
	8.4	39.6	70.5	0.512	6.1
	6.0	22.1	39.8	0.281	4.7
	8.2	-	-	-	-
	10.7	13.2	44.8	0.715	6.7
	11.0	15.8	63.3	0.990	9.0
	16.6	21.1	132.0	2.434	14.7
	2.0	14.5	55.4	0.741	37.0
	5.8	18.5	79.0	0.968	16.7
	8.5	24.9	72.9	0.92	13.8
	14.7	25.0	238	1.660	11.3
	4.6	55.8	155	0.777	16.9
	4.4	14.8	86	0.568	12.9
	6.6	14.5	121	0.851	12.9
	13.3	30.3	277	1.915	14.4
	11.9	17.1	279	2.132	17.9
	-	-	-	-	-
	8.4	25.0	74	0.387	4.6
	4.8	11.9	90	0.708	14.8
	8.6	24.3	165	1.12	13.2

Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949

TABLE A-5 - PRODUCTION DATA

	Date	Charge				Blast			Water	
		Ore Tons	Coke Tons	Lime-stone Tons	Open-hearth slag Tons	Air c.f.m.	Temperature °F.	Pressure lbs per sq. in.	To furnace M.G.D.	Recir to w M.
Furnace A	August 9	1,513	660	345	69	72,400	1,090	18.0	5.06	3.
	10	1,473	641	338	68	73,900	1,115	18.0	5.08	3.
	11	1,438	651	338	68	75,000	1,125	18.0	4.98	3.
	12	1,441	641	356	67	74,600	1,070	18.0	4.75	2.
	15	1,509	637	346	67	69,200	1,015	18.0	5.22	3.
	16	1,709	694	380	73	73,700	1,010	18.5	5.28	3.
	17	1,704	713	385	74	75,600	1,060	18.5	5.34	3.
	18	1,566	656	347	68	56,500	1,155	18.0	5.25	3.
	19	1,626	679	348	71	52,800	1,185	18.5	5.27	3.

PRODUCTION DATA

	Water		Production				Casting time
Pressure lbs. per sq. in.	To furnace M.G.D.	Recirculated to washer M. G. D.	Pig iron Tons	Gas M.C.F.	Dry flue dust Tons	Dry flue dust % Ore	
18.0	5.06	3.80	798	83.1	25	1.7	9:10 AM;1:45,6:30,11:50 PM,4:00 AM
18.0	5.08	3.60	809	80.6	25	1.7	9:00, 1:45, 6:30, 11:10, 3:50
18.0	4.98	3.60	809	82.1	25	1.7	8:55, 1:50, 6:30, 11:20, 4:25
18.0	4.75	2.10	782	80.7	25	1.7	9:45, 2:55, 6:35, 11:25, 4:10
18.0	5.22	3.69	848	8[illegible].3	30	2.0	8:50, 1:45, 6:55, 11.10, 4:40
18.5	5.28	3.70	811	87.4	45	2.6	9:05, 1:50, 6:50, 11:10
18.5	5.34	3.60	890	89.8	35	2.1	9:00, 1:35, 6:35, 11:05, 3:55
18.0	5.25	3.45	881	82.7	35	2.2	9:00, 2:15, 6:40, 11:20, 3:55
18.5	5.27	3.50	915	85.6	30	1.8	8:45, 2:25, 6:20, 10:50, 3:45

Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N. Y.
August, 1949.

TABLE A-5, Continued - PRODUCTION DATA

		Charge				Blast			Water	
	Date	Ore Tons	Coke Tons	Lime-stone Tons	Open hearth slag Tons	Air c.f.m.	Temperature °F.	Pressure lbs per sq. in.	To furnace M.G.D.	Recirculated to washer M. G. D.
Furnace B	August 9	1,621	692	418	-	59,100	1,020	15.0	4.73	2.00
	10	1,535	645	390	-	52,900	1,070	16.5	4.77	2.01
	11	1,483	688	411	-	58,100	1,135	16.0	4.73	1.99
	12	1,558	675	412	-	59,300	1,040	16.0	4.75	1.95
	15	1,544	641	383	-	56,000	1,060	16.0	4.77	2.03
	16	1,498	680	415	-	57,100	1,145	16.0	4.82	2.07
	17	1,588	658	242	-	58,000	1,075	15.5	4.95	2.05
	18	1,575	654	367	-	53,100	1,075	15.5	5.00	2.05
	19	1,608	645	388	-	55,900	1,145	16.0	5.02	2.06
Furnace C	August 9	2,051	992	527	153	83,600	985	16.0	4.07	1.81
	10	2,074	968	549	153	83,500	915	16.0	4.37	1.39
	11	2,021	956	531	148	82,200	955	16.0	4.45	1.30
	12	1,989	948	539	146	82,700	900	16.0	4.32	1.40
	15	1,910	871	508	135	78,200	870	16.0	4.55	1.91
	16	2,076	972	568	148	80,700	930	17.0	4.62	1.84
	17	1,942	996	512	149	80,500	1,040	17.0	4.70	1.77
	18	1,923	932	542	143	82,200	910	16.0	4.69	1.80
	19	2,098	923	509	143	83,100	845	16.0	4.67	1.76

-5, Continued - PRODUCTION DATA

Pressure lbs per sq. in.	Water		Production				Casting time
	To furnace M.G. D.	Recirculated to washer M. G. D.	Pig iron Tons	Gas M.C.F.	Dry flue dust Tons	Dry flue dust % Ore	
15.0	4.73	2.00	810	87.2	60	3.7	6:30 AM,12:00 N,4:40, 9:00, 1:50 PM
16.5	4.77	2.01	766	81.2	30	2.0	7:05, 11:45, 4:45, 9:00, 1:25
16.0	4.73	1.99	803	86.8	40	2.7	6:45, 12:35, 4:15, 9:15, 2:05
16.0	4.75	1.95	719	85.1	30	1.9	6:35, 10:50, 5:00, 9:05, 2:00
16.0	4.77	2.03	850	80.8	40	2.6	6:50, 11:40, 4:50, 9:15, 2:15
16.0	4.82	2.07	654	85.7	25	1.7	6:25, 11:15, 4:25, 9:20, 2:20
15.5	4.95	2.05	884	82.9	25	1.6	6:40, 11:55, 4:40, 9:10, 2:15
15.5	5.00	2.05	809	82.4	20	1.3	7:20, 12:10, 5:10, 10:20, 1:45
16.0	5.02	2.06	836	81.3	15	0.9	6:30, 11:40, 4:55, 9:00, 2:30
16.0	4.07	1.81	1,059	125.5	40	2.0	8:05 AM,1:10,6:00,10:45 PM,3:35 AM
16.0	4.37	1.39	1,170	124.5	30	1.4	8:00, 12:45, 5:45, 10:15, 3:10
16.0	4.45	1.30	1,020	120.5	70	3.5	8:05, 12:50, 5:50, 10:25, 2:50
16.0	4.32	1.40	1,078	119.5	80	4.0	8:25, 11:00, 6:15, 11:10, 3:00
16.0	4.55	1.91	957	109.8	30	1.6	8:05, 1:40, 6:05, 10:05, 2:50
17.0	4.62	1.84	1,099	122.5	30	1.4	8:05, 12:50, 5:35, 10:30, 3:05
17.0	4.70	1.77	1,467	125.5	35	3.3	8:15, 1:15, 5:25, 10:25, 2:50
16.0	4.69	1.80	966	117.4	30	1.6	8:10, 12:00, 5:45, 10:50, 2:55
16.0	4.67	1.76	1,001	116.3	25	1.2	7:55, 12:45, 6:20, 10:25, 2:50

Blast Furnace Department
Bethlehem Steel Co.
Lackawanna, N.Y.
August, 1949

TABLE A-5, Continued - PRODUCTION DATA

	Date	Charge				Blast			Water	
		Ore Tons	Coke Tons	Lime-stone Tons	Open-hearth slag Tons	Air c.f.m.	Temperature °F.	Pressure lbs per sq. in.	To furnace M. G. D	Recirc to wa M. G
Furnace C	August 9	1,950	1,061	525	158	69,600	1,000	17.0	6.40	3.
	10	1,876	996	484	151	70,400	1,000	16.0	6.40	3.
	11	1,180	1,013	480	150	69,500	965	17.0	6.30	3.
	12	1,953	980	472	151	69,400	900	17.0	6.30	3.
	15	1,496	878	393	124	62,500	1,005	18.0	6.35	3.
	16	1,486	818	361	120	64,600	945	18.0	6:30	2.
	17	1,792	899	404	136	70,500	870	17.5	6.30	3.
	18	1,925	899	468	139	68,500	850	18.0	6.25	2.
	19	1,825	907	468	135	70,000	985	19.0	6.25	3.
Furnace E	August 9	2,232	1,215	463	180	86,800	975	20.0	5.47	3.
	10	2,139	1,142	414	173	85,100	955	20.5	5.52	3.
	11	2,232	1,207	432	180	89,000	935	20.5	5.50	3.
	12	2,139	1,142	456	173	86,200	940	19.5	5.51	3.
	15	2,294	1,215	481	185	89,300	970	19.5	5.72	3.
	16	2,338	1,247	516	193	87,800	935	19.0	5.44	3.
	17	2,310	1,247	501	193	86,700	925	19.5	5.54	3.
	18	2,174	1,134	432	174	88,200	880	20.5	5.50	3.
	19	2,276	1,158	459	179	85,500	840	20.5	5.58	3.

nued - PRODUCTION DATA

	Water		Production				Casting time
Pressure lbs per sq. in.	To furnace M. G. D.	Recirculated to washer M. G. D.	Pig iron Tons	Gas M.C.F.	Dry flue dust Tons	Dry flue dust % Ore	
17.0	6.40	3.63	1,127	132.0	50	2.6	6:15 AM, 12:10, 4:20, 8:25 PM, 1:05 AM
16.0	6.40	3.36	1,106	125.5	60	3.2	6:10, 11:10, 3:30, 8:20, 1:25
17.0	6.30	3.31	1,064	127.5	50	2.7	6:00, 11:10, 3:45, 8:20, 1:15
17.0	6.30	3.11	1,127	123.0	50	2.6	6:15, 11:00, 3:30, 8:30, 12:50
18.0	6.35	3.17	882	110.1	40	2.7	6:30, 11:05, 3:25, 8:50, 12:10
18.0	6:30	2.42	866	103.1	30	2.0	6:15, 10:45, 3:55, 8:00, 1:00
17.5	6.30	3.26	709	113.3	40	5.6	5:55, 10:25, 3:15, 7:55, 1:05
18.0	6.25	2.97	960	113.3	50	2.6	5:40, 11:10, 4:00, 8:20, 1:10
19.0	6.25	3.11	1,139	114.3	60	3.3	5:50, 10:55, 3:30, 7:55, 1:10
20.0	5.47	3.13	1,436	153.0	55	2.5	10:25 AM, 2:45, 7:35 PM, 12:10, 5:00 AM
20.5	5.52	3.22	1,425	143.5	50	2.3	10:40, 3:10, 7:10, 12:20, 5:10
20.5	5.50	3.21	1,426	152.0	50	2.2	10:35, 2:55, 7:35, 12:25, 5:00
19.5	5.51	3.24	1,497	143.5	75	3.5	10:00, 3:10, 7:45, 2:10, 7:10
19.5	5.72	3.29	1,477	153.1	65	2.8	10:30, 2:30, 7:15, 12:15, 5:05
19.0	5.44	3.12	1,399	157.1	45	1.0	10:45, 2:20, 7:20, 12:35, 5:10
19.5	5.54	3.22	1,397	157.1	65	4.7	10:20, 2:30, 7:30, 12:10, 5:20
20.5	5.50	3.22	1,419	142.9	60	2.8	10:05, 2:35, 7:25, 12:05, 5:00
20.5	5.58	3.26	1,322	145.9	65	2.9	10:30, 2:30, 7:20, 11:35, 4:45

SECTION B

COKE PLANT WASTES

October 16 - November 15, 1951

by

Gerald N. McDermott, S. A. Sanitary Engineer

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SECTION B

COKE PLANT WASTES

Description of Process

The process consists of carbonizing suitable mixtures of crushed coal under carefully controlled conditions to produce coke for use in the blast furnaces and also to produce fuel gas for various plant heating operations.

For purposes of clarity of exposition, the coke plant proper will be treated in the following discussion under two main divisions:

(A) Coke Ovens and By-Product Plant - consisting of those units which function to carbonize the coal to coke and to recover, from the gas, by-products such as tar, ammonium sulfate, sodium phenolate, naphthalene, and light oil.

(B) Benzol Plant - wherein light oil recovered from the gas is separated from wash oil and refined for production of its fractions.

Coke Ovens and By-Products Plant

A flow diagram for this division of the operations appears in Figure B-1.

Carbonization

The by-product coke plant operates 383 coke ovens, arranged in six batteries. Three batteries, consisting of 57 ovens per battery, are of the Koppers type, with each oven having a capacity of 13 tons of coal, giving 9.4 tons of coke per charge. One battery of 60 ovens is of the Semet-Solvay type, with a capacity of 15 tons of coal per oven, capable of producing 10.8 tons of coke per charge. Two batteries are of the Wilputte type, consisting of 76 ovens per battery, with each oven having a capacity of 15.6 tons of coal, capable of producing 11.3 tons of coke per charge.

Mixed and crushed coal is delivered to storage bins above each block of ovens. A larry car is filled from the storage bins and moved into position above the oven to be charged. After the doors are replaced on the oven and sealed, the oven is charged. Fuel gas is burned in flues located in the brickwork between each oven chamber. The air for combustion is preheated in regenerator checkerwork located below the ovens.

Temperature is controlled by changing the volume of gas input according to fuel value. The average flue temperature of the ovens during this survey was 2468°F and the average coking time 15.5 hours. This is a higher temperature than used when the production of the plant is not being maintained at the maximum consistent with wear on equipment. Pro-

50-A

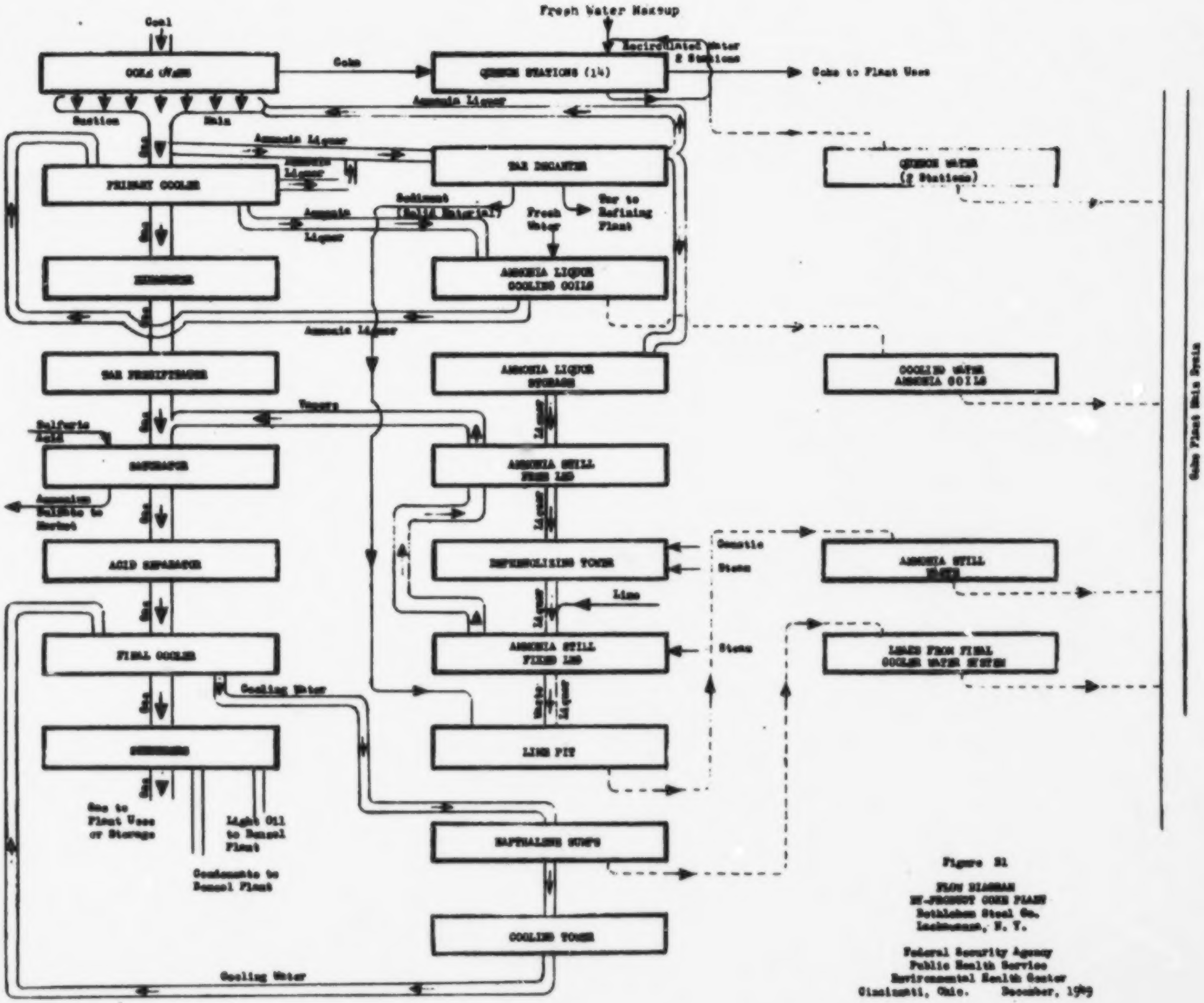
Coal
COKE OVENS
Suction
Main
Coke
QUENCH STATIONS (14)
Fresh Water Makeup
Recirculated Water 2 Stations
Coke to Plant Uses
Ammonia Liquor
Gas
PRIMARY COOLER
Ammonia Liquor
TAR DECANTER
Sediment (Solid Material)
Tar to Refining Plant
Fresh Water
Ammonia Liquor
EXHAUSTER
AMMONIA LIQUOR COOLING COILS
Ammonia Liquor
TAR PRECIPITATOR
AMMONIA LIQUOR STORAGE
Vapors
Sulfuric Acid
SATURATOR
Ammonium Sulfate to Market
AMMONIA STILL FREE LEG
Liquor
ACID SEPARATOR
DEPHENOLIZING TOWER
Caustic
Steam
Lime
AMMONIA STILL FIXED LEG
Steam
FINAL COOLER
Cooling Water
Water
LIME PIT
SCRUBBERS
Gas to Plant Uses or Storage
Light Oil to Benzol Plant
Condensate to Benzol Plant
NAPTHALENE SUMPS
COOLING TOWER
Cooling Water
QUENCH WATER (2 Stations)
COOLING WATER AMMONIA COILS
AMMONIA STILL WASTE
LEAKS FROM FINAL COOLER WATER SYSTEM
Coke Plant Main Drain

Figure 21

FLOW DIAGRAM
BY-PRODUCT COKE PLANT
Bethlehem Steel Co.
Lackawanna, N. Y.

Federal Security Agency
Public Health Service
Environmental Health Center
Cincinnati, Ohio.   December, 1949

duction of coke was maintained at the maximum in co-ordination with peak operation of the steel mill in defense production. Usual temperatures and times for optimum economy are about 2300°F and 19 hours.

Quenching and Coke Handling

When carbonization is complete, the incandescent coke is pushed out of the oven with a ram, operated by a mechanical pusher, through a coke guide on the opposite end of the oven and into the quenching car. The quenching car is then run to one of four quenching stations, where the coke is quenched with water. Following this, the coke is dumped onto a wharf, from which it is transferred to a screening station for processing.

The amount of water used in quenching must be just sufficient to quench the coke without leaving it wet.

Gas Collection

Volatile materials and gases released from the coal during the coking period are conducted through standpipe uptakes into the collector main. Ammonia liquor, pumped directly from the ammonia liquor and tar decanter tanks, is sprayed continuously into this main. Cooling of the gas that occurs in the collector main condenses most of the tar. The liquor flushes the tar from the conductor. Some of the liquor may evaporate and saturate the gas, while the remainder persists in the liquid state. Both gas and liquor travel through the collector main to the suction main. At this point, the ammonia liquor flows by gravity back into the tar decanter tanks. The gases are drawn through the suction main and enter at the bottom of the primary coolers.

Primary Cooling

There are six primary coolers, operated in parallel. Gas entering at the bottom of the cooler ascends to the top, passing through an arrangement of wooden laths with which the cooler is packed. Cooled ammonia liquor is continuously flowing down over these laths and comes into direct contact with the gas, thereby cooling the gas from about 80°C to about 30°C. This cooling results in condensation of most of the water vapor and other volatile material carried by the gas. The condensate contains, in solution, ammonia, chlorides, sulfides, cyanides, phenol, and other materials; and tar in suspension. The ammonia liquor used for cooling purposes in the primary cooler is recirculated from the bottom of the cooler, being pumped through cooling coils and thence back to the top of the cooler. Surplus liquor, over and above that which is recirculated, flows by gravity into the ammonia liquor tar decanter tanks. In these latter tanks, tar settles by gravity and is pumped to storage tanks. Ammonia liquor (in excess of that pumped to the collector main) is stored and processed for recovery of ammonia and phenol.

Ammonia Recovery

In order to recover ammonia, the liquor is processed in a steam stripping still, consisting of three sections. In the first section - free leg - the liquor is stripped of the so-called free ammonia (mostly dissolved ammonia) by the direct steam from the top of the fixed leg of the still. The liquor from the free leg (after passage through the dephenolizing tower) enters the second section of the still, a conical tank, where it is mixed with milk of lime. The mixture of the liquor and lime overflows into the third section - the fixed leg - where the ammonia, which is liberated by the chemical action of the lime upon ammonium salts, is stripped from the liquor by direct low-pressure steam entering the bottom of the column. The still vapor from the top of the free leg goes into the gas stream ahead of the ammonium sulfate saturator. Waste liquor from the bottom of the fixed leg discharges into a settling sump for removal of lime solids, and then passes into the main coke plant drain.

Immediately following the free leg of the still, and prior to its mixture with the lime in the second section, the ammonia liquor is processed for phenol recovery in a Koppers vapor recirculation dephenolizing tower. A detailed discussion of this unit will be found on page 89.

Exhausters and Precipitators

From the primary coolers the gas passes through the exhausters. These are centrifugal compressors which maintain a suction on the gas coming from the ovens and provide a pressure on the gas leaving the exhausters. This pressure serves to force the gas through the remaining processes and finally to the gas distribution system. A constant pressure of 16" (water gage) is maintained on this system by a small gas holder.

Next the gas is passed through tar precipitators where finely dispersed tar is removed in a high-tension electrically charged field. The tar is drained off through a seal and goes into the tar decanter.

Saturators

Oven gas plus recovered ammonia from the ammonia still is sent to the sulfuric acid saturator to remove ammonia by formation of ammonium sulfate. The gas enters the bottom of the unit and passes upward through a spray of 5-1/2 to 6 per cent sulfuric acid, which reacts with the ammonia in the gas to form ammonium sulfate. Liquor containing the sulfate crystals collects in the conical-shaped bottom of the unit. The crystals are removed continuously from the base of the saturator, passed through centrifuges for dewatering, dried in a Roto Louvre drier, and placed in storage for shipment. Liquor removed in the centrifuge is recirculated through the saturator. Sulfuric acid, 60° Be, is added at the suction of the recirculating pump to maintain the acid strength at the proper level.

Following the saturator, acid that may have carried over in the gas is removed in acid separators. Acid from this process is returned to the saturator for re-use.

Final Cooling

The gas from the acid separators goes to final cooling towers where the gas is again cooled with water sprays to remove heat of compression of the exhausters and heat from the saturators. These are also of the direct type, i.e., there is direct contact between the cooling water and the gas. Cooling water washes down over wooden grids with which the cooler is packed, and removes by its action substances such as naphthalene, cyanide, and residual ammonia, from the gas. The water is then run into two skimming pits, where the naphthalene rises to the surface, is skimmed off, and added to the tar in the tar storage tanks. The liquor leaving the skimming pit is pumped to the top of a Marley cooling tower, where its temperature is reduced by allowing it to rain down through an air draft. The cooled liquor is recirculated to the top of the final coolers, to go through the process again (see also page 93).

Light Oil Extraction

Gas leaving the final coolers enters the light oil scrubbers. The scrubbers are two cylindrical upright steel tanks 17' in diameter and 110' high, which operate in parallel. These scrubbers are packed with new type Koppers spiral steel packing. Wash oil enters at the top and flows down through the packing countercurrent to the upward flow of gas. The wash oil absorbs the light oils present in the gas. Wash oil containing the dissolved light oil is pumped to the benzol plant. Forty to 45% of the gas leaving the scrubbers is conducted through pipe lines to the ovens for use as fuel gas to supply the heat for the coking process. The remaining 55% to 60% is used in the steel plant. When the volume of gas produced exceeds the amount used, the excess is bled. The bleed averages about 1.4% of the total coke oven gas produced.

Benzol Plant

Wash oil and its absorbed light oil is processed in the benzol plant: first, for the separation of the light oil from the wash oil and, secondly, for the fractionating of the recovered light oil to its benzol, toluol, xylol, heavy crude solvent naphtha, residue, and forerunnings components. The details of these two processes are described in the two subsequent sections.

Light Oil Recovery Plant

The wash oil draining into the base of the scrubbers (referred to as benzolized wash oil) is pumped to the light oil recovery plant. This plant separates light oil from wash oil by steam distillation. The light oil leaves the column of the stripping still as vapor: the vapor is condensed and light oil recovered. The wash oil is cooled and recirculated. Reference is made to Figure B-2, a flow diagram of the plant. In detail, the benzolized wash oil, at about 28°C, first enters at the bottom of the vapor-to-oil heat exchanger, flows upward through the tubes, and is heated by the mixture of steam and light-oil vapors flowing downward in the space around the tubes (the steam and light oil vapors coming from the stripping still).

Separation of a small amount of the water present in the benzolized wash oil is accomplished in the heat exchanger, the oil being drawn off at the top and water from the bottom. This condensate passes into a separator, the oil recovered being returnèd to the wash oil, the water going to the intercepting sump.

The benzolized oil, after leaving the vapor-to-oil heat exchanger, enters a final heater, where its temperature is further raised by indirect heating with high-pressure steam. The benzolized oil, at 110°C, now enters the stripping column, near the top, whence it flows downward countercurrent to upflowing steam. Steam is admitted directly at the base of the tower. Light oils are carried off at the top of the column with the steam, while hot debenzolized wash oil flows down to the base of the column and thence to the hot oil tank.

The hot debenzolized wash oil in the hot-oil tank is then pumped

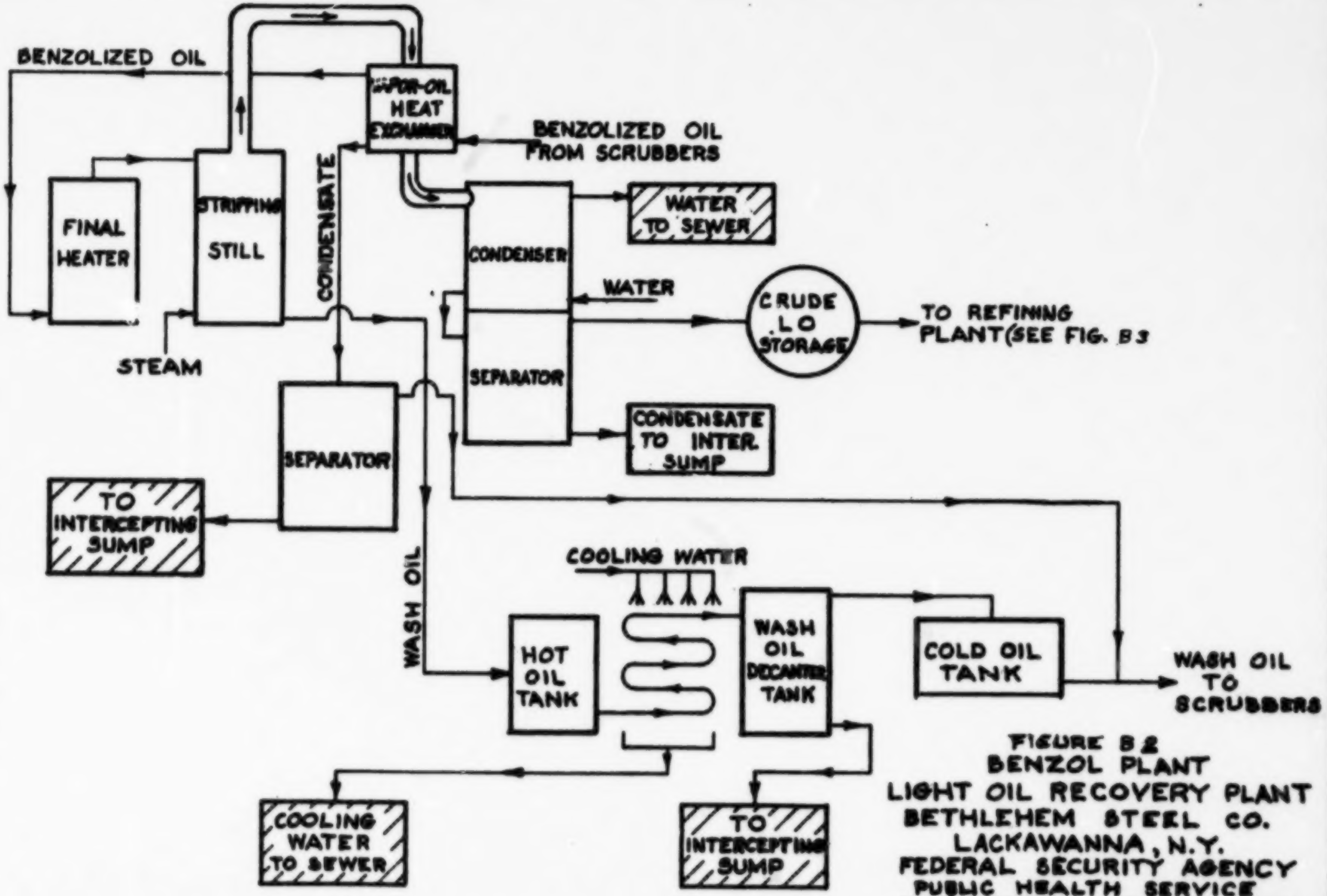
BENZOLIZED OIL
VAPOR-OIL HEAT EXCHANGER
BENZOLIZED OIL FROM SCRUBBERS
FINAL HEATER
STRIPPING STILL
CONDENSATE
STEAM
CONDENSER
SEPARATOR
WATER TO SEWER
WATER
CRUDE L.O. STORAGE
TO REFINING PLANT(SEE FIG. B3
CONDENSATE TO INTER. SUMP
SEPARATOR
TO INTERCEPTING SUMP
WASH OIL
COOLING WATER
HOT OIL TANK
WASH OIL DECANTER TANK
COLD OIL TANK
WASH OIL TO SCRUBBERS
COOLING WATER TO SEWER
TO INTERCEPTING SUMP

FIGURE B2
BENZOL PLANT
LIGHT OIL RECOVERY PLANT
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

through the wash oil cooling coils to the decanter tank and from there goes to a cold oil tank, from which it is pumped to the top of the benzol washers to begin the cycle anew.

The steam and light oil vapors leaving the top of the stripping still enter the vapor-to-oil heat exchanger to raise the temperature of the incoming benzolized oil. On leaving the heat exchanger, the vapors enter a condenser wherein indirect water cooling causes condensation to occur. The condensate then enters a separator from which light oil is decanted into crude light oil tanks where it is stored prior to refining operations. Steam condensate is run to the intercepting sump.

There are two Koppers stills of 12,000 gallons of light oil per day capacity and one Wilputte still with 8,000 gallons capacity. Exhaust steam at approximately 10 psi and amounting to 0.75 pound per gallon of wash oil, is fed to the stills.

Light Oil Refining Plant

The light oil is purified and separated into its pure products in the refining plant. First the highly volatile unsaturated components are removed in a forerunnings column. Following this operation, the light oil is separated in the crude still into a benzol-toluol-xylol fraction (BTX), a heavy crude solvent naphtha fraction, and residue. The BTX fraction is subsequently purified by acid and caustic washes in a batch agitator. The BTX fraction is then processed in a residue remover column. In the final step, accomplished by the pure still, the BTX is separated into benzol, toluol, and xylol. (Reference is made to Figure B-3, a flow diagram of the process). Details of each operation are given in subsequent sections.

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(a) Forerunnings Column (Fig. B-3) - The term "forerunnings" refers to the most volatile fraction of the crude light oil and usually constitutes 1 to 3 per cent by volume of the crude light oil. Its precise composition is susceptible to slight changes in plant operations and may vary from day to day. Highly unsaturated, its chief components are found to be cyclopentadiene (C_5H_6), carbon disulfide (CS_2), and the amylenes (C_5H_{10}). These compounds are removed from the crude light oil in the forerunnings still, operation of which is as follows.

The crude light oil is pumped from storage into the column, entering somewhat above the middle of the column. The function of this column is to effect as complete a separation as possible between the forerunnings and the balance of the light oil. The column is a 3' diameter, 36 plate still in which approximately 2 to 2.5 per cent of forerunnings are removed. The top product is condensed and the forerunnings separated from the water in a decanter. The product take-off is refluxed at the same rate as the feed rate. The forerunnings are introduced to the gas main and are entirely volatile. The water is sent to the intercepting sump. Light oil is drawn from the bottom of the column through a cooler to storage. The heat for the distillation is supplied by a reboiler located at the bottom of the column.

(b) Crude Still - In the crude still the light oil, now free from forerunnings, is separated into three fractions: a BTX component, heavy crude solvent naphtha, and residue. This is a semi-batch still having a 30,000-gallon kettle and a 36 plate, 10' diameter fractionating column. The light oil is charged to the kettle

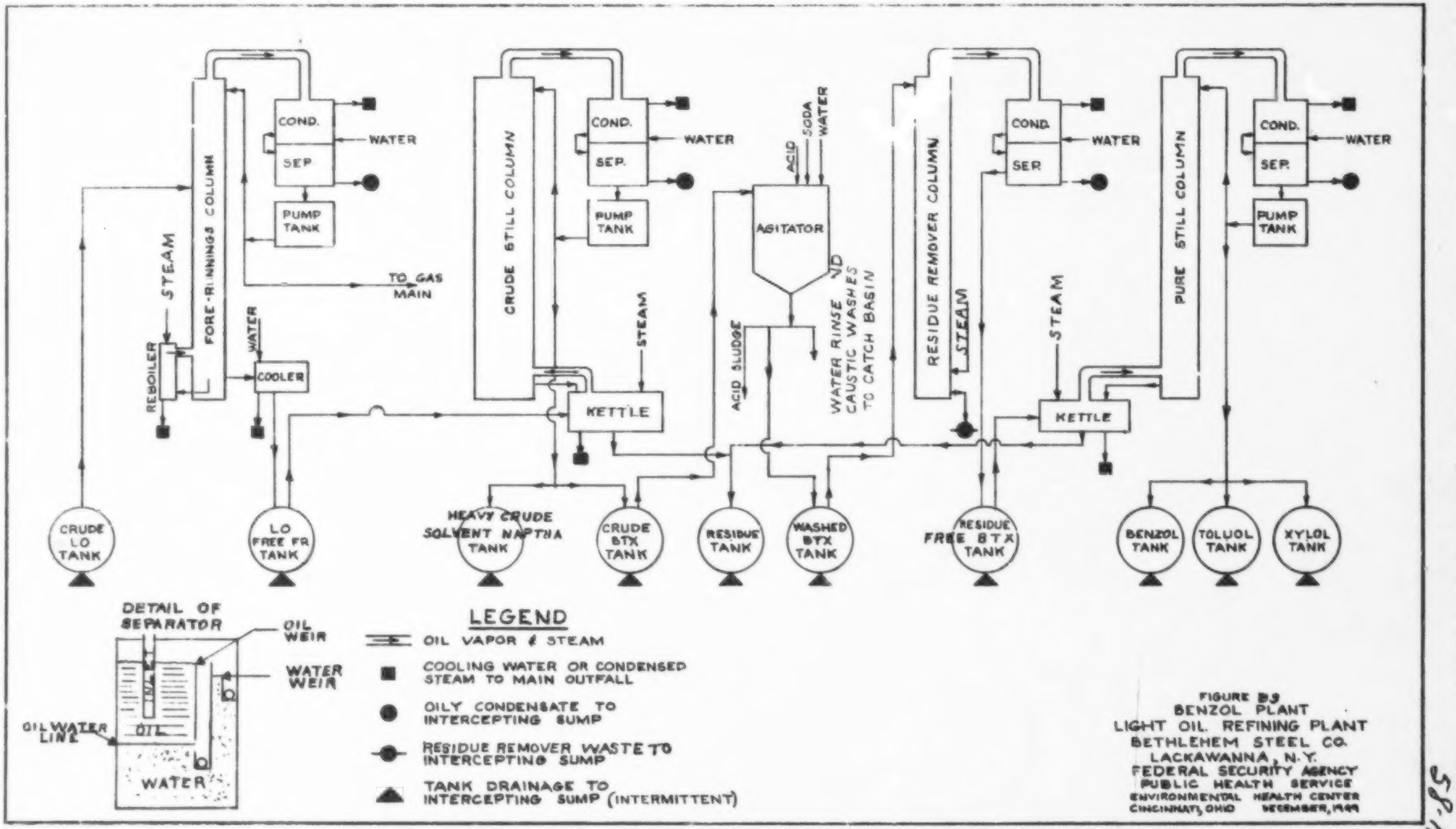
COND.
SEP.
WATER
PUMP TANK
FORE-RUNNINGS COLUMN
STEAM
REBOILER
WATER
COOLER
TO GAS MAIN
CRUDE STILL COLUMN
STEAM
KETTLE
ACID
SODA
WATER
AGITATOR
ACID SLUDGE
WATER RINSE AND CAUSTIC WASHES TO CATCH BASIN
RESIDUE REMOVER COLUMN
STEAM
SER.
PURE STILL COLUMN
STEAM
KETTLE
CRUDE LO TANK
LO FREE FR TANK
HEAVY CRUDE SOLVENT NAPTHA TANK
CRUDE BTX TANK
RESIDUE TANK
WASHED BTX TANK
RESIDUE FREE BTX TANK
BENZOL TANK
TOLUOL TANK
XYLOL TANK
DETAIL OF SEPARATOR
OIL WEIR
WATER WEIR
OIL WATER LINE
INLET
OIL
WATER
LEGEND
OIL VAPOR & STEAM
COOLING WATER OR CONDENSED STEAM TO MAIN OUTFALL
OILY CONDENSATE TO INTERCEPTING SUMP
RESIDUE REMOVER WASTE TO INTERCEPTING SUMP
TANK DRAINAGE TO INTERCEPTING SUMP (INTERMITTENT)

FIGURE B9
BENZOL PLANT
LIGHT OIL REFINING PLANT
BETHLEHEM STEEL CO.
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in 20,000-gallon batches and the kettle heated indirectly by steam. The vapor from the kettle passes into the fractionating column, meeting the liquid reflux coming down. Liquid reaching the bottom of the column is returned to the kettle. The desired product is taken off the top of the column as vapor, condensed, and separated from entrained water. The BTX fraction is separated from the first batch. After BTX is separated from the first batch to about 70 per cent of the volume of the charge, a second 20,000-gallon batch is added and BTX separation continued. The heavy crude solvent naphtha and residue accumulate in the kettle. After about three charges of light oil, the heavy crude solvent naphtha and residue occupy a considerable portion of the volume of the kettle. At this point the product distillation range is adjusted and naphtha is drawn from the column. During the heavy crude solvent naphtha run, direct steam is used for distillation in the kettle.

After the naphtha run, the still is charged for the fourth time in the cycle and BTX is again separated. After about the sixth charge and BTX separation, heavy crude solvent naphtha is fractionated again. The cycle is then completed with pumping of residue from the kettle to a residue-storage tank. The kettle is then ready for a fresh charge.

Each of the products, BTX and naphtha, pass from the top of the column to condensers. The product is separated from condensed water in decanters, the water going to the intercepting sump. When necessary, inhibited motor fuel can be produced, but this was not done during the survey. The BTX fraction makes up about 95 per cent of the products, the naphtha 1.7 per cent, and 3.16 per cent is residue.

(c) Agitator - In order to remove undesirable compounds, crude BTX is subjected to successive washings with sulfuric acid, water and caustic soda.

The oil to be washed is pumped into the agitator, which is an 8,000-gallon cylindrical tank fitted with a conical bottom. When oil to be processed has been added, concentrated sulfuric acid is introduced, and the mass of oil and acid is agitated so that intimate contact between the two is effected. Following agitation, there is a period of quiescence allowing stratification of oil and acid sludge. The sludge drain piping is then opened, and the acid sludge produced is drained into sludge cars. This sludge is an intimate mixture of unused acid, entrained light oil, and reaction products ("resins"). Sludge is dumped on the bank of Smokes Creek.

Following a second acid wash, the agitator contents are washed with water, followed by settling. The water is then discharged to the catch basin.

A wash with an aqueous solution of caustic soda is then carried out, the caustic wash waste being discharged to the sewer also.

Following the caustic wash, the BTX is washed with water. This water is also discharged to the catch basin.

This treatment of a batch of crude BTX takes a few hours. One batch is usually washed each shift. Following the treatment, oil is stored in the washed BTX tank.

(d) Residue Remover Column - Undesirable corrosive compounds are separated from the washed BTX in a 4' diameter, 9 plate column known as the residue remover column. This is also referred to at other plants as the residue boiler (or R.B.) column. Direct steam is used. The top product, consisting of the purified BTX and steam, is condensed, the water separated and sent to the intercepting sump, while the BTX goes to storage tanks. The material remaining on the bottom of the still is drained into the intercepting sump. This waste appears to be a pernicious emulsifying agent.

(e) Pure Still - The pure still separates the purified BTX product of the residue stripper into pure products consisting of benzol, toluol and xylol. It is a semibatch still having a 26,000-gallon kettle and a 30 plate, 6' diameter fractionating column. The BTX is charged to the kettle in batches and the kettle heated indirectly by steam. The vapors pass from the top of the still to condensers. Water is separated from the oil condensate in decanters. The water flows to the intercepting sump. A portion of the oil is used for reflux. The balance goes to storage tanks. After fractionating benzene from about three charges, toluol is separated. After six charges, the distillation range is adjusted so that xylol is separated. Residue remaining in the kettle is pumped to the residue tank.

Residue from the crude and pure still is sold. This combined crude and pure still residue contains about 30% naphthalene. The yield of salable products from the crude light oil is approximately 71% benzol, 9.0% toluol, 1.5% xylol, 1.7% solvent naphtha, and 4.0% still residue. The over-all refining and distillation losses in processing the crude light oil amount to 12-13%.

Gas Producer

The demand for fuel gas in the plant is greater than the supply. A producer gas unit (three producers) is operated adjacent to No. 4 battery to furnish gas for the No. 4 battery of coke ovens. It is more practical to burn 126 B.T.U. producer gas for underfiring coke ovens than 510-515 B.T.U. coke oven gas which can be used to better advantage in other parts of the plant. Pea coke (1/2 to 3/4" size) is burned in the producers. It is necessary for Bethlehem Steel Company to purchase coke on the open market. This coke is shipped by rail and the cars may contain considerable coal fines which find their way into the pea coke, since the pea coke is screened from the total coke used at the blast furnaces.

The producers are large, water-jacketed steel shells with a gas outlet and a device for admitting the coke, at the top; and a steam-air tuyere inlet and ash-removal system at the bottom. The water jacket prevents side-wall clinker and furnishes low-pressure steam for mixing with the air. There are rotating grates for continuous ash removal and for helping to maintain even distribution of the coke. The gases from the producers are passed down through a waste heat boiler which produces high-pressure steam. Dust settles out of the gas in passing through this heat exchanger and is removed at the bottom of the unit. The producer gas finally passes up through a water cooler to coke oven battery No. 4. The cooling water is sprayed into the top of the tower and cools and washes the gas as it flows down over wooden hurdles countercurrent to the flow of gas. It is then diverted past the producers for the purpose of flushing ashes to a pit. The pit supernatant finally flows through a coarse screen to a sewer leading to the main coke plant drain.

WASTE SOURCES AND DISPOSAL

Coke Oven and By-Product Coke Wastes

The three principal sources of liquid wastes at this plant are ammonia still waste, cooling water for the ammonia liquor coils, and coke-quenching water. Other wastes of minor importance are cooling water for the air compressors and drainage from the coke wharves. The final cooler water recirculation system has leaks of very small volume but considerable importance. Each of these waste sources is discussed in sections following.

Ammonia Still Waste

This waste originates in the moisture contained in the coal charged to the coke ovens, which is later condensed from the gases plus the dilution from direct steam and lime slurry addition it receives in the ammonia still. Some water is also considered to be constituted in the ovens.

Cooling Water - Ammonia Liquor Coils

The ammonia liquor to be returned to the primary gas coolers is cooled by passing it through pipes over which cold water is made to flow. The cooling pipes are 2 inch diameter steel pipes, 20 feet long, which are placed in tiers horizontally, one directly above the other, 40-high. The pipes are connected at opposite ends alternately to pipes above and below with 180° elbows. The bottom pipe connects to a header supplying hot ammonia liquor and the top pipe to a header carrying away the cold ammonia liquor. The coils of pipes are built in groups of fifty, and four groups make up the total. Cold water is distributed along the top pipes and flows down over the 40 pipes beneath to a cold basin and thence to the sewer.

This water would not be expected to be contaminated but leaks are quite common and a continuous maintenance problem. Also tar and naphthalene in the ammonia liquor is prone to form deposits in the pipe. In fact, the critical factor in operation of the coils is to be certain that the temperature of the liquor is not reduced below 28°C, else naphthalene crystallization will seriously affect operation. For this reason, in the winter when the water is cold, reduced quantities of cooling water are used. The pipes are checked regularly as to temperature reduction accomplished in each. When a coil is not functioning properly, it is cut out, drained and cleaned. In preparation for cleaning or repair, the coils are drained into the cooling water. It has been estimated that on the average three or four coils are drained each day and as many as 32 may be drained. Coils are drained during a period of a few hours on the day shift when repairs are made. Each coil contains about 130 gallons; therefore, on the average, 400 or more gallons of ammonia liquor are dumped each day and as much as 4100 gallons may be dumped. It is of importance to note that no coils were drained during the sampling conducted on this survey, for the reason that these slug discharges are incompatible with the composite sampling program used.

Quench Water

As explained in the process description, the coke is quenched soon after it is removed from the ovens. Water is sprayed on the incandescent coke in the quenching car, at quenching stations. Much of the water evaporates and is drawn up the stack of the quenching station but a large amount passes through the load of coke and is drained to a small rectangular settling basin. The more readily settleable small particles of coke carried in the water settle out in the basins. The basins are periodically dredged of the fine coke sediment, called coke breeze.

The length of the spraying period in the quenching station is regulated automatically at 2-1/2 minutes. The car remains about an additional 1/2 minute while the water is draining off. Several minutes later, another load is ready for quenching. On the average, the length of time when no water is being sprayed is 7-1/4 minutes.

This plant operates four quenching stations as shown on Figure B-4. Two of these, A and B, recirculate the water, pumping it from the settling basin back to the tank supplying the sprays. These recirculating stations do not have sufficient storage capacity associated with the settling basin to make the recirculation system function properly. For this reason, considerable volumes of water flow to waste, even from the recirculating stations.

At the nonrecirculating stations, the basin effluents flow to waste. This flow would be expected to be somewhat intermittent. The spray water supply tanks are equipped with float valves which are supposed to cut off the flow when the water approaches the overflow level of the tanks. Actually the valves were not functioning properly, so that considerable water passed via an overflow to the quenching station settling basin even when not quenching.

After a quenching car leaves the quenching station, some water continues to drain from the car. After the coke is dumped on the coke wharf, quenching is completed and the moisture content regulated by spraying with hand hose. This water drains to waste.

The final coolers are equipped with a water recirculation system which was thought to be completely closed, with no waste of water to the sewers whatsoever. This water system had emergency drainage gates and a plank stop gate which evidence showed were leaking a small quantity of water to waste.

A small quantity of cooling water is used to cool the cylinders of an air compressor supplying air to the ovens.

Benzol Plant Wastes

Wastes of the benzol plant consist of cooling water, condensed water separated from the oily material being processed, waste caustic wash, acid and caustic rinse water from purifying the BTX, and residue removed in the residue remover column. Before going to waste, all condensates and the residue waste pass initially through an intercepting sump, which is a small oil-skimming basin, for recovery of oil carried with the condensate. These wastes then pass through a second skimming basin referred to as the catch basin. The wastes of the acid wash and rinse and the cooling water pass directly to the catch basin which is also for the purpose of recovering oil. All wastes combine in the catch basin and leave the plant in the main benzol plant sewer.

Cooling Water

Cooling is entirely indirect, so that no pollutional material should be added. However, for some coolers, leakage could be into the cooling water.

Condensate

The vapors leaving the top of fractionating columns are condensed and water separated from the oily material continuously by means of special type decanters (Figure 8-3). These decanters contain two weirs, over one of which the oil flows, and the other, at a slightly lower elevation, allows the water to leave the decanter. The oil weir acts as a baffle and maintains a layer of oil under which the water passes. The water then rises and flows over the water weir. The source of this water is water contained in the benzolized wash oil as it is delivered from the light oil scrubbers, water added in those columns using direct steam distillation, and water remaining in the BTX from that added in the acid and caustic wash and rinses. Direct steam distillation is employed for the heavy crude solvent naphtha fractionation in the crude still and in the residue stripper. There is a small amount of water separated from the benzolized wash oil in the vapor-to-liquid heat exchanger of the light oil recovery plant. Also some water is separated from the recovered wash oil after it is cooled and prior to its being returned to the scrubbers. Some water separates in each of the oil storage tanks and in the bottom of the reboilers or kettles. This condensate is drained to waste intermittently by manual operation. To this class belongs the water which collects below the benzolized wash oil in the bottom of the scrubbers. The scrubber is arranged so that the benzolized wash oil is drawn off at an elevation well above the bottom. In the space below this drawoff, water accumulates and is manually drawn off intermittently and pumped to the intercepting sump in the benzol plant.

Agitator Wastes

The rinse water is added to the acid-washed BTX, the mixture is agitated a few minutes, and then separated over a short quiescent period and drained to waste. Approximately 400 gallons of water are used. The caustic wash utilizes 225 gallons of a 20%, by weight, solution of caustic soda in the same manner. The BTX is rinsed again with a second 400 gallons of water. These wash and rinse wastes are dumped in batches, usually once each per shift.

Residue from Residue Remover

This residue is the precipitate from the acid-caustic wash which is not separated by settling in the agitator.

Gas Producer Wastes

Wastes of the gas producer units consist of the gas-cooling water which is sprayed into the top of the producer gas washer and flows down over hurdles countercurrent to the flow of gas. This water is then conducted to a recessed trough beneath the automatic ash-removing mechanism on the bottom of the gas producer. The ashes fall to the trough and are sluiced by a rapid flow of the washer water to a pit in which much of the ashes settles out. The supernatant finally flows through a coarse screen to a sewer leading to the main coke plant drain. Ashes are dredged from the pit each shift.

OPERATION SCHEDULE AND PRODUCTION DATA

Coke Oven and By-Product Plant

Operation of the coke oven and by-product plant is continuous, 24 hours per day, 7 days per week.

Average daily production figures for the days on which samples were collected are tabulated below. Production figures for each day are given in Table B-6 in Appendix B at the end of this section.

Average Production and Operation Data

Flue temperature	2,468 °F
Coking time	15.7 hours
Dry coal coked	7,827 tons
Wet coal coked	8,298 tons
Coke	5,815 tons
Gas	84.1 MCF
Ammonia liquor	139,215 gallons
Ammonium sulfate	150,387 pounds
Light oil	25,821 gallons
Tar	51,256 gallons
Sodium phenolate	416 gallons

Benzol Plant

The light oil recovery plant operates continuously, 24 hours per day, 7 days per week. Operations of some of the units of the light oil refining plant are continuous, the semibatch distillation units operate more or less continuously, but the agitator caustic wash and rinse water wastes are definitely batch dumps.

The forerunnings column and the residue remover operate continuously. In each of the crude and pure stills a charge is processed in about 18-22 hours. With charging and heating time, about one charge is fractionated each day. Considering, first, crude still operation, about every third and sixth day heavy crude solvent naphtha would be fractionated during some hours of operation and every sixth day residue would be removed. Direct steam distillation employed on these days probably results in some variation in waste volume and character. In the pure still, toluol would be separated about every third and sixth day, during a few hours, and about every sixth day xylol would be separated.

Dumping of the agitator acid rinse, caustic wash, and caustic rinses occurs over periods of about five minutes each. The three usually follow in a series, with less than an hour between individual dumps. The series is usually dumped once each shift.

Daily production figures, for the days on which samples were collected, are as follows:

Date 1951	Benzol gals	Toluol gals	Xylol gals	Heavy Crude Solvent Naphtha gals
Oct. 28	16,515	4,698	0	1,881
30	23,248	0	0	0
31	30,962	0	0	0
Nov. 5	18,724	1,850	0	2,021
6	21,064	4,147	0	0
7	30,633	0	0	0
8	3,586	3,540	1,785	-
12	14,513	3,152	0	0
13	12,940	0	0	0
Average	19,132	1,921	198	434

SURVEY PROCEDURES

Sample Collection

Samples were collected manually at frequent intervals throughout the day and night. Individual samples of equal size, taken from 7 AM to 7 AM were composited to represent the day's waste. Samples likely to be variable were collected every 15 minutes; others were collected at 30-minute intervals. As flows were fairly constant, compositing according to flow was unnecessary.

Separate samples were collected for the phenol and cyanide determinations. The phenol samples were preserved by adding approximately 4 gms of copper sulfate per liter to carboys before sampling. The cyanide samples were preserved by adding pellets of sodium hydroxide to the carboys before sampling.

Flow Measurements

A record of measurements of waste flows is tabulated below:

Date of Measurement 1951	Quantity of Flow* Mgd	Point of Measurement and Remarks
(a) Main Coke Plant Drain		
Oct. 26	16.4	
31	16.8	
Nov. 12	17.1	Measured by current meter at point just upstream from junction with North quench station drain
14	17.2	
15	16.5	
Average Flow from Water Stage Record		
Nov. 5	16.9	
6	17.6	
7	18.0	
8	17.3	
14	16.8	
15	16.9	
16	16.9	
Average	17.2	

* Quantity of flow of North quench station; 0.5 MGD has been added to these flow figures.

Date of Measurement 1951	Quantity of Flow MGD	Point of Measurement and Remarks
(b) Ammonia Coil Cooling Water		
Oct. 29	10.8	Measured by current meter at point just above junction with main coke plant drain.
31	12.5	
Nov. 12	13.0	
14	11.5	
15	13.1	
Average	12.2	
(c) Gas Producer Waste		
Oct. 30	0.64	Measured by V-notch weir installed against outlet of ash sump. Average flow for one day obtained.
(d) Upper Main Coke Plant Drain		
Nov. 12	1.46	Measured by current meter just above junction with ammonia still waste sewer. Flow here originates in following sources: Gas producer Air compressor cooling Quench station A overflow Leaks of Marley cooling tower recirculating system.
13	1.94	
14	1.14	
15	1.43	
Average	1.49	
(e) Central Quench Station Drain		
Nov. 15	5360 gals per quench waste flow	Measured by current meter in trench above junction with main coke plant drain. Meter placed at 7 stations in section of trench (36" wide) and left at each station continuously for 10 to 12 minutes. Number of quenches during measuring period, 10:29 AM to 12:22 PM, was 24. (North quench station was out of operation).

Date of Measurement 1951	Quantity of Flow MGD	Point of Measurement and Remarks
(f) Benzol Plant Outfall Sewer		
Nov. 2	6.68	Measured by Pitot tube at mouth of sewer.
6	5.60	
7	5.54	
8	5.38	
(g) Benzol Plant Intercepting Sump Discharge		
Nov. 2	0.162	Measured by pumping through a meter during period of 2 to 4 hours. Flow was in excess of pump capacity; excess flow was measured by rise of water level in sump.
8	0.179	
9	0.173	
Average	0.171	

(h) Ammonia Still Waste

Volume of ammoniacal liquor fed to still as reported by Bethlehem was multiplied by factor of 1.2 for dilution from steam and lime slurry. Feed was measured by the drop in liquid level in liquor storage tanks.

Laboratory Procedures

Laboratory procedures used for phenol, cyanide and thiocyanate, are given in detail in the main Appendix at the end of the report. The pH was determined colorimetrically, with initial checks by pH meter.

EXPLANATION OF ANALYSES

The materials for which analyses were made have significance to water pollution in that they are toxic to aquatic life, produce taste and odor, or otherwise have bearing on subsequent water uses. Each of the determinations is discussed in detail in the main Appendix at the end of the report.

RESULTS

Volume and Character of Wastes

The average concentrations of certain pollutants in the wastes as discharged are shown in Table B-1. These determinations do not include all measurements of coke plant wastes but only those of interest to the particular survey.

Since the raw water used in plant operations contained some of these materials, deductions of the concentrations in the raw water were made where appropriate to arrive at the amount produced by plant operations during sample compositing periods. Data so adjusted appear as part of Table B-1 and are referred to as net concentrations. Table B-1 also contains data as to the average total gross and net quantity of each of these constituents discharged daily. The gross average quantities are the average of daily quantities; the net averages are computed from the average of daily concentrations and flows. As explained subsequently, the survey revealed that a leak in the final cooler water recirculation

Coke Plant
Bethlehem Steel Co.
Lackawanna, N.Y.
Oct.-Nov., 1951

Table B-1 - Gross and Net Average Concentrations and Quantities of Wastes

Component	Phenols ppm	Cyanides as CN ppm	Thiocyanates as CNS ppm	Ammonia as N ppm	Oil ppm	pH Range	Flow Average MGD	Phenols ppm	Cyanides as CN ppm	Thiocyanates as CNS ppm	Ammonia as N ppm	Oil ppm
	Gross Average Concentrations							Net Average Concentrations				
Raw water pump station No. 10	0.13	<0.1*	<4 *	0.55	26.7							
Ammonia still waste	41.0	26.1	322	32.4		7.3-7.6	20.					
Cooling water-Ammonia liquor	.26	.11	<4			11.4-11.6	0.167	41.0	26.1	322	32.4	
Quench water	1.55	< .1				7.5-7.6	12.2	.13	< .1	<4		
Gas producer waste	10.0	1.5	<4	.68		6.8	1.02	1.46	< .1			
Main coke plant drain	2.1	.32	<4	4.0			.64	9.9	1.5	<4		
Intercepting sump benzol plant	48.6	23.4	69.2			7.5-7.6	17.3	2.0	.3	<4	3.4	
Benzol plant main sewer	1.9	.52	<4		32.8		.171	48.6	23.4	69.2		
Upper main coke plant drain	16	2.8				7.3-7.8	5.89	1.8	.5	<4		6.1
							1.49	15.9	2.8			
	Gross Average Quantities							Net Average Quantities				
	lbs	lbs	lbs	lbs	lbs			lbs	lbs	lbs	lbs	lbs
Raw water pump station No. 10	21.7			91	4432							
Ammonia still waste	57	35	448	45			20					
Cooling water-Ammonia liquor	26.1	10.7					0.167	57	35	448	45	
Quench water	13.2						12.2	13.2				
Gas producer waste	53.1	8.0		5.8			1.02	12.4				
Main coke plant drain	313	53		570			.64	52.8	8.0			
Intercepting sump benzol plant	69.0	33.2	129				17.3	288	43.2		486	
Benzol plant main sewer	92.1	25.1			1500		.171	69.0	33.2	129		
Upper main coke plant drain	198	55.2					5.89	88.3	24.6			299
							1.49	197.3	34.8			

* Concentration of cyanide in sample was below the lower limit of quantitative accuracy of the method of determination employed.

system was contributing about half of the phenol present in the main coke plant drain. Such leakage would not be a normal waste of a coke plant, so cognizance should be taken of this factor when considering data for the main coke plant drain. In computing the averages, those concentrations below the lower limits of quantitative accuracy of the analytical methods employed were considered as zero.

Flows for each of the individual wastes appear in Table B-1. A tabulation of individual determinations appears in the Appendix at the end of this section.

A schematic diagram of the sewer system of the coke oven and by-product plant area is shown in Figure B-4. Sampling station locations are designated on the drawing.

Discussion of Results

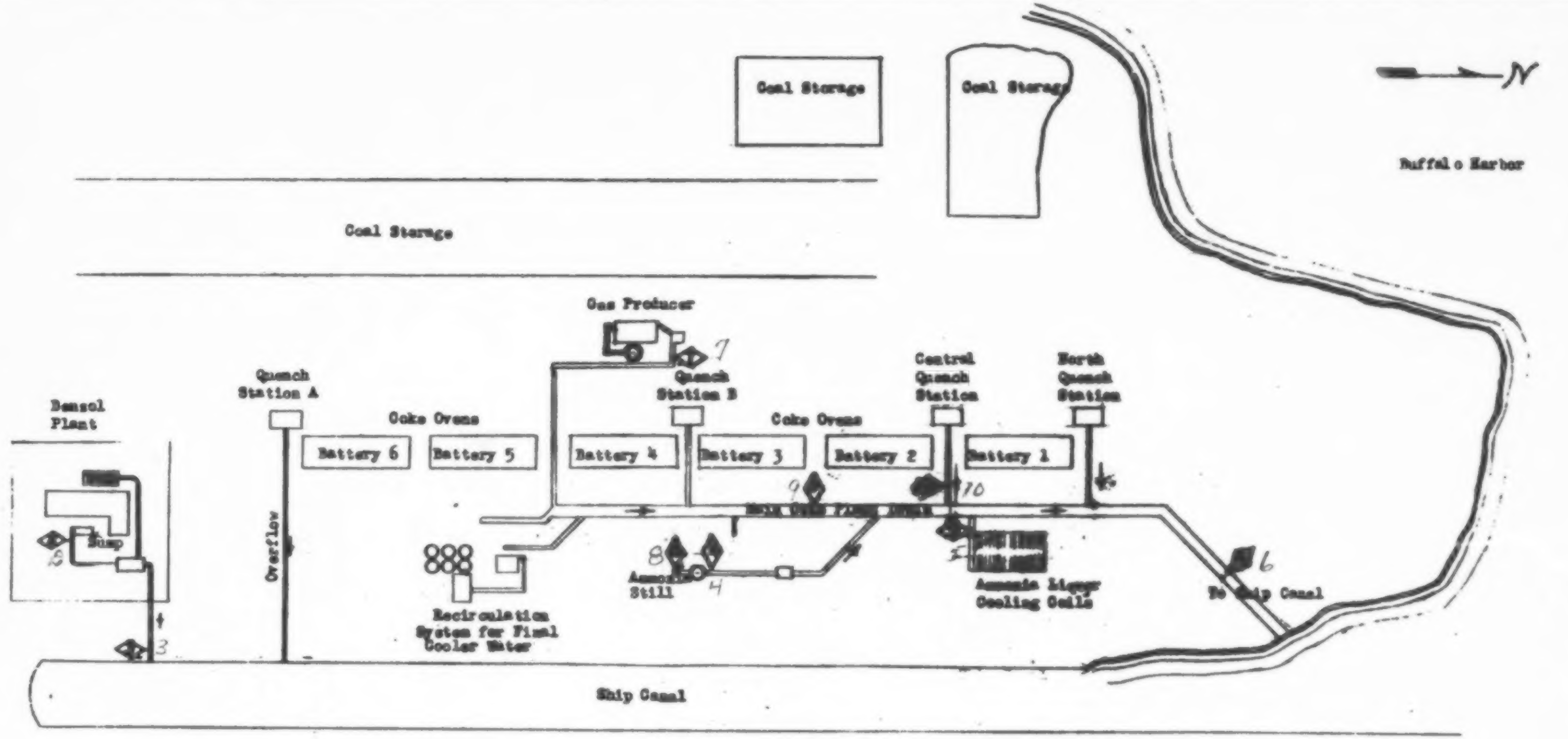
A discussion of the results and consideration of the balance of the quantities of pollutants in the main drains, versus that in the component wastes, follows. In general, results at each sampling station were quite consistent.

Coke Oven and By-Product Plant

(a) Balance of Quantities in Main Sewer versus Components - The two wastes of this division in which the concentrations of the phenols, cyanides and thiocyanates were anticipated as being significant, were ammonia still waste and ammonia liquor cooling water. These wastes combined with quench water, gas producer wastes and miscellaneous minor wastes, to constitute the flow in the main coke plant drain. As shown in Table B-2, the average quantity of phenol in three contributing wastes during the first nine sampling days did not sum up to the average daily quantity found in the main coke plant drain by 181 pounds. In order to determine the source of this phenol, which was not apparent, sampling stations were shifted to include all wastes. Sampling at the gas producer was discontinued and replaced by sampling at a point on the upper section of the main coke plant drain, Point 9 on Figure B-4. The waste flow at this point consists of the gas producer waste, overflow from quench station B, and miscellaneous wastes such as the air compressor cooling water. Quench water from the central quench station was also sampled and the sampling point on the main drain was shifted upstream above the North quench station waste drain junction.

The balance of phenols achieved during the next two sampling days was much closer. An average of 198 pounds of phenol was found in the upper coke plant drain. The gas producer had averaged 53 pounds in previous testing. An additional 5 pounds or so might come from the quench water overflow. Therefore a source contributing some 140 pounds (198 minus 58) of phenol was revealed in this area.

The over-all balance during these last two sampling days averaged 74 pounds discrepancy. However, the phenol concentrations in the main coke plant drain were considerably higher than the average. Compared to the average quantity of phenol in the coke plant drain, the quantity in the contributing wastes during the last two days is in close agreement.


N
Buffalo Harbor
Coal Storage
Coal Storage
Coal Storage
Gas Producer
7
Benzol Plant
Sump
2
3
Quench Station A
Overflow
Coke Ovens
Battery 6
Battery 5
Battery 4
Quench Station B
Coke Ovens
Battery 3
Battery 2
Central Quench Station
North Quench Station
Battery 1
9
10
Main Coke Plant Drain
Recirculation System for Final Cooler Water
8
Ammonia Still
4
5
Ammonia Liquor Cooling Coils
6
To Ship Canal
Ship Canal

LEGEND OF SAMPLED STATIONS

Numeral Designation	Waste or Point
2	Benzol Plant Intercepting Sump
3	Benzol Plant Outfall Sewer
4	Ammonia Still Waste
5	Ammonia Liquor Cooling Water
6	Main Coke Plant Drain
7	Gas Producer Waste
8	Ammonia Still Inflow
9	Upper Main Coke Plant Drain
10	Quench Water Waste - Central Station

Figure 14
Schematic Diagram

SEWER SYSTEM OF COKE PLANT

Bethlehem Steel Co.
Lackawanna, N. Y.

Public Health Service
Environmental Health Center
Cincinnati, Ohio December 1951

Coke Plant
Bethlehem Steel Co.
Lackawanna, N.Y.
Oct. - Nov., 1951

Table B-2 - Quantity of Phenols in Main Coke Plant Drain, versus Contributors

	Station No. (Ref. Fig. B-4)	Gross Phenol lbs	Flow MGD
For First Nine Days of Sampling, Averages			
Contributing wastes			
Ammonia still waste	4	49	0.167
Cooling water - ammonia liquor	5	30	12.2
Gas producer waste	7	53	.64
Total of above		132	13.0
Main coke plant drain	6	313	17.2
Difference		-181	- 4.2
For Last Two Days of Sampling, Averages			
Contributing wastes			
Ammonia still waste	4	88	0.169
Cooling water - ammonia liquor	5	9	12.2
Quench water -- central station	10	13	1.02
Upper coke plant drain	9	198	1.49
Total of above		308	14.8
Main coke plant drain above N.quench station		382	16.3
Difference		-74	- 1.5

At the suggestion of the coke plant superintendent, inspection of emergency waste gates and a plank stop of the final cooler water circulation system revealed that leakage was the logical source of this phenol. Computations based on values of the phenol content of the recirculated waters obtained at a previous time showed that a leakage on the order of 6 gpm would contribute about 150 pounds of phenol. The sewer was underground, with outlet submerged, so flow could not be observed.

The flow balance during the last two days, Table B-2, was fairly close. It is considered likely that the volume of quench water is actually greater than the 1.02 mgd listed. This figure was obtained by measuring the flow and counting the number of quenches during a period when an unusually high number of quenches per hour were being carried out. The rapid rate of quenching at this station was necessary because other quench stations were not operating. Because of the rapid rate of quenching, flow was quite steady and easily measured. From such data, a figure of gallons of waste per quench was obtained and the total flow computed by multiplying this value by the number of quenches during a day. Actually it appeared that the quench waste flow averaged about the same, as previously explained, regardless of the rate of quenching. If true, quench water volume would be great enough to make the flow balance much closer.

(b) Ammonia Still Waste - Phenol concentration in the ammonia still waste averaged only 41 ppm, which is unusually low for such wastes. This may be accounted for by the fact that coking temperatures employed were somewhat higher than when operation for optimum economical production governs. The high temperatures currently employed are for the purpose of obtaining maximum production for defense demands.

As a check on these data and in the interest of determining the efficiency of the still, several 24-hour composite samples of ammonia still inflow were obtained. These data confirmed the belief that phenol production was well below that of plants operating at the more usual coking temperatures. The inflow averaged only 850 ppm. Table B-3, comparing the inflow and effluent data, is presented below. A 93% reduction is shown in the quantity of phenol contained in the liquor. This does not represent phenol recovery efficiency, as considerable phenol is volatilized and returns to the gas stream with the ammonia vapors.

This waste was the major source of cyanide in the main coke plant drain, averaging 26.1 ppm concentration and containing 57 pounds.

The waste also contained thiocyanates in high concentration, averaging 322 ppm.

(c) Cooling Water - Ammonia Liquor - Pollutants enter the water by leaks of ammonia liquor. From October 28 through November 8, gross phenol concentration progressively increased from less than 0.01 ppm to 0.88 ppm. On November 12 the concentration was down to 0.12 ppm and remained of that order for succeeding days. This concentration is approximately equal to that of the raw water. During the highest days, leakage was about 60 pounds of phenol per day. At 850 ppm concentration in the liquor, a leakage of

Table B-3 - Reductions in Ammonia Still

Date 1951	Phenol			Cyanide as CN			Ammonia as N		
	p. p. m.		%	p. p. m.		%	p. p. m.		%
	Inflow	Effluent	Reduction*	Inflow	Effluent	Reduction*	Inflow	Effluent	Reduction*
Nov. 12	776	37.6	94.2						
13	878	36.1	95.1						
14	867	54.9	92.4	49.9	23.8	43	5,910	36.9	99.3
15	878	70.5	90.3	48.9	22.6	45	6,010	28.0	99.4
Average	850	49.8	93.0	48.4	23.2	44	6,000	32.4	99.3

* Allowing for 20% dilution.

8480 gallons is indicated, or about 6 gallons per minute. Leaking coils are shut off when discovered, which probably accounts for the build-up and drop in the results.

As discussed in a previous section of the report, on Wastes Sources, ammonia liquor in the coils, to be repaired or cleaned, is drained to waste with the cooling water. This was not done during this survey. Considering this ammonia liquor to have the phenol content of the ammonia still feed, the phenol added by these dumps would average about 2.8 pounds during each day shift and, at a maximum, would be 29 pounds.

For the reason that coils were deliberately not drained during this survey, an additional quantity of phenols contributed by these dumps must be included in the results reported, to obtain an estimate of the total quantity of phenol normally discharged.

Concentrations of cyanide and thiocyanate in this waste were below the lower limit of quantitative accuracy of the analytical method used.

(d) Quench Water - The two composite samples of quench water averaged 1.55 ppm of phenol. The raw water averaged 0.09 ppm phenol content for the two days. The net contribution to quench water was 1.46 ppm. Waste from the two quench stations which do not recirculate the quench water is near 5300 gallons per quench. The two stations contributed about one million gallons of water per day. The appearance of phenol in the waste might not be anticipated; however it is in agreement with data showing that a small quantity of phenol is created by combustion of coke in blast furnaces and gas producers.

Concentrations of cyanide and thiocyanate in this waste were below the lower limit of quantitative accuracy of the analytical method used.

Benzol Plant

Practically all of the significant wastes of this benzol plant are contained in the intercepting sump overflow. The other significant wastes, i.e., acid rinse, caustic wash, and caustic rinse waters from the agitator, do not flow to the intercepting sump. These wastes join the cooling water to form the total flow in the outfall sewer of the benzol plant. As shown in Table B-1, the average quantity of phenol and cyanide in the intercepting sump agrees closely with the quantities found in the main outfall. The wastes reaching the sewers from the agitator were not sampled themselves but as part of the outfall samples. The results indicate they contributed small quantities of phenol.

Little variation was shown in flow from the intercepting sump by measurements made over a few hours each on four days. The concentration of phenols and cyanides in the wastes varied only slightly from day to day. Evidently the batch operation of certain stills does not affect the wastes to such extent that variations are not fairly averaged out in the sump.

The results show that the benzol plant was discharging quantities of phenol of the order of 1-1/2 times that of the ammonia still waste. The benzol plant was shown to contribute a considerable part of the cyanide in the plant wastes. Thiocyanates were also present, but the quantity was only a fraction of that of the ammonia still waste.

Gas Producer

This waste was found to contain an average of 10 ppm phenols, which amounts to 53.1 pounds per day. This quantity was rather unexpected. However, combustion of coke in blast furnaces is known to produce small quantities of phenols. It is believed that at least some of this phenol originates from the coal fines which are contained in the coke. Considerable coke is purchased from other producers. Such purchased coke is shipped in railroad cars that are also used to transport coal. Some coal fines remain in the cars and mix with the coke. All coke fines are conveyed to the gas producers. Plant officials state that in such fines the coal dust content is appreciable.

SUMMARY

On the basis of the data and supporting information presented in this report, certain pertinent points may be summarized, as follows.

Net quantities of certain significant constituents discharged daily from the main coke plant drain, benzol plant outfall, and contributory sources, under the conditions prevailing during sampling, averaged as follows. Volumes of flow are also shown.

Sewer or Source	Net Quantities			
	Phenol lbs	Cyanide as CN lbs	Ammonia as N lbs	Flow MGD
Main coke plant drain	288	43.2	486	17.3
Ammonia still waste	57	35	45	.167
Cooling water ammonia liquor	13.2			12.2
Quench water waste	12.4			1.02
Leaks of final cooler water	140			
Gas producer waste	52.8	8.0		.64
Benzol plant outfall	88.3	24.6		5.89
Intercepting sump discharge	69	33.2		.171

Unit values of quantities and flow of each of the sewers and sources are as follows:

Sewer or Source	Net Quantities per Ton of Coal Carbonized			
	Phenol lbs	Cyanide as CN lbs	Ammonia as N lbs	Flow gals
Main coke plant drain	0.0347	0.0052	0.0585	2080
Ammonia still waste	.0068	.0042	.0054	20.1
Cooling water ammonia liquor	.0016			1470
Quench water waste	.0015			123
Leaks of final cooler water	.0169			
Gas producer waste	.0064	.00096		77.1

	Net Quantities per 1000 Gallons of Light Oil Recovered		
	Phenol lbs	Cyanides as CN lbs	Flow gals
Benzol plant main sewer	3.42	0.952	228,000
Intercepting sump discharge	2.67	1.29	6,620

The average yield of coke and by-products from carbonization of one ton of coal is as follows:

Coke	1,424 lbs
Gas	10,100 cu. ft
Ammonium sulfate	18.1 lbs
Tar	6.18 gals
Light oil	3.11 gals
Sodium phenolate	0.0501 lbs

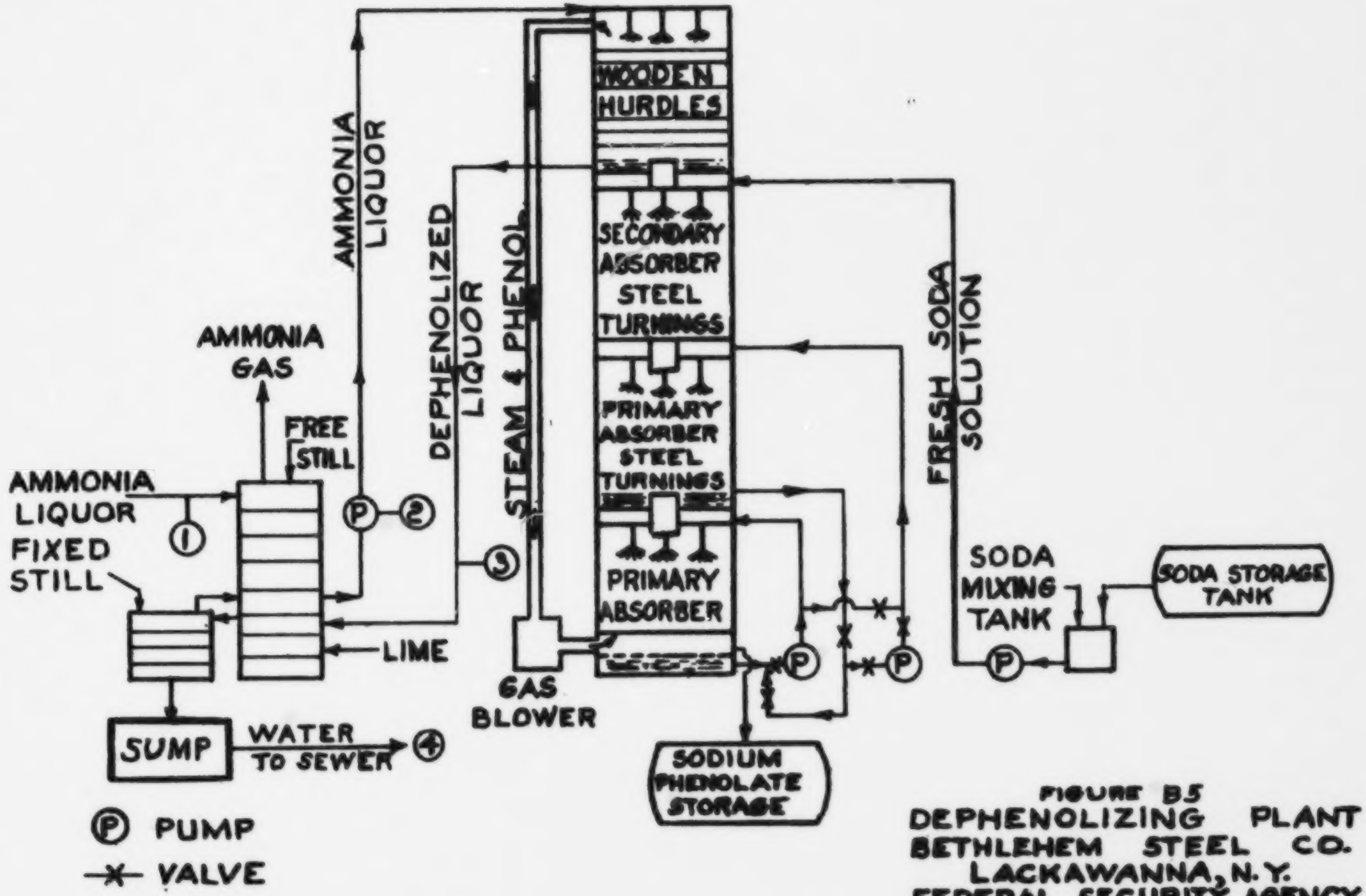

AMMONIA LIQUOR
FIXED STILL
①
AMMONIA GAS
FREE STILL
Ⓟ ②
AMMONIA LIQUOR
DEPHENOLIZED LIQUOR
③
LIME
SUMP
WATER TO SEWER ④
STEAM & PHENOL
GAS BLOWER
WOODEN HURDLES
SECONDARY ABSORBER STEEL TURNINGS
PRIMARY ABSORBER STEEL TURNINGS
PRIMARY ABSORBER
Ⓟ
Ⓟ
SODIUM PHENOLATE STORAGE
FRESH SODA SOLUTION
Ⓟ
SODA MIXING TANK
SODA STORAGE TANK
Ⓟ PUMP
—✕— VALVE

FIGURE B5
DEPHENOLIZING PLANT
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

SPECIAL STUDIES

September, 1949

by

Charles E. Sponagle
Assistant Sanitary Engineer

During the course of the survey, several studies of a special nature were carried out. These are described below.

Phenol Recovery Tower and Ammonia Still

Phenol is recovered from the weak ammonia liquor by means of a Koppers vapor recirculation tower. Arrangement of the ammonia still, phenol tower, and necessary appurtenances, is shown in Figure B-5.

Ammonia liquor leaving the free leg of the ammonia still is pumped through distributing sprays to the top section of the dephenolizing tower where it passes down over wooden hurdles, countercurrent to the steam flow. The liquor then flows by gravity from the bottom of the top section of the tower to the lime section of the ammonia still. The three bottom sections of the tower are absorbing sections, where a salable sodium phenolate of approximately 35% tar acids is produced.

The phenol-enriched steam is recirculated from the top to the bottom of the tower and passes upward through the two lower sections which contain steel turnings and in which sodium phenolate containing free soda is recirculated. The third section (from the bottom) is packed with steel turnings which are kept wet with a fresh solution of 10% soda pumped by a soda "shot" pump, working by a timer from a mixing tank. This section absorbs the last traces of phenol before the steam re-enters the top liquor section.

The caustic solution progressively overflows to the section below until it becomes of sufficient concentration to be salable sodium phenolate. The sodium phenolate builds up to the required strength in the bottom of the tower and is discharged into a storage tank.

The tower operates under a slight top pressure of 6-10 inches of water. In order to keep noncondensable gases out of the circulating vapor, some bleed is maintained at all times. A set of high-pressure steam coils in the bottom and second section supplies heat to make up radiation and bleed losses. The tower is completely enclosed with insulating materials.

On September 28 and 29, samples were collected at the following points in the dephenolizing plant:

	Sample Collected from	Code number on Fig. 9
Ammonia still influent	Cock on pump	1
Influent to Koppers tower	Cock on pump	2
Effluent of Koppers tower	Return line to ammonia still	3
Ammonia still effluent	Discharge line to sewer	4

These samples were 4-hour composites, portions being collected at 15-minute intervals by a Public Health Service employee. Approximately one gallon of sample was obtained at each point.

Flows could not be measured at any of the four sampling points. Company records provided information as to the volume of still feed (point 1), and the empirical factor of 1.2 was again used to estimate the still discharge (point 4). Assuming that the increase in flow was uniformly distributed between the free leg and fixed leg of the ammonia still, the flows shown in Table 4 are obtained.

Procedures used for phenol and cyanide analyses will be found in the main appendix at the end of the report.

Table B-4 presents the data obtained in this study.

Based upon this two-day study, the following conclusions may be drawn: (1) in the free leg of the ammonia still there is stripped from the ammonia liquor 29% of the phenol and 63% of the cyanide, (2) the phenol tower removes 87% of the phenol from the incoming liquor and 58% of the cyanide, (3) In the fixed leg of the ammonia still there is removed from the liquor 7.7 % of the phenol and 2.6 % of the cyanide remaining after passage through the free leg and the dephenolizing tower, (4) a total of 604 pounds of phenol was returned to the oven gas with the ammonia vapor. This represents 30% of the phenol present in the feed to the ammonia still. A total of 15.6 pounds of cyanide is likewise returned to the oven gas, representing 64% of the cyanide present in the ammonia liquor entering the still, (5) the combined action of the ammonia still and phenol tower resulted in a 92% removal of phenol from the ammonia liquor, and an 85% removal of cyanide.

Coke Plant
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949
Jan., 1950

TABLE B-4, AMMONIA STILL AND DEPHENOLIZING TOWER

Special Study

	Phenol							Cyanide						
	p. p. m.			Flow M.G.D.	Pounds per day			p. p. m.			Flow M.G.D.	Pounds per day		
	9/28	9/29	Avg.		9/28	9/29	Avg.	9/28	9/29	Avg.		9/28	9/29	Avg.
Influent to ammonia still	2060	2310	2190	0.112	1920	2160	2040	21.0	29.5	25.3	0.112	20.3	28.6	24.5
Influent to Koppers tower	1370	1460	1420	0.123	1400	1500	1450	6.0	10.9	8.5	0.123	6.4	11.6	9.0
Effluent from Koppers tower	183	183	183	0.123	187	187	187	3.3	3.8	3.6	0.123	3.5	4.0	3.8
Effluent from ammonia still	155	353*	155	0.134	173	394*	173	3.0	3.3	3.2	0.134	3.5	3.8	3.7

* Not used in average.

Final Cooler System - Marley Tower

As previously described (page 55) in the coke oven by-product operations, it is necessary to cool the gas after it leaves the saturators and prior to its passage through the benzol washers. This is done in final coolers - towers equipped with grids and water sprays for direct contact cooling of the gas. The cooling water used for this purpose is contained in an enclosed recirculation system, no waste being discharged from this process.

Cooling water discharged from the final coolers first passes through naphthalene skimming sumps, where the naphthalene condensed from the gas rises to the surface and is recovered. The water then is conducted through a covered concrete trench below ground level to a concrete hot well. It is pumped from this well to distribution basins on top of the Marley cooling tower. These basins are fitted with nozzles for distributing the water evenly over the redwood strips with which the tower is filled. The water trickles down over these wooden strips and is cooled approximately 20°F by a continuous flow of air which is induced by two 184-inch fans. The cooled water flows into a cold well, from which it is pumped to the top of the final coolers, to pass through this sequence of operations again.

On January 3, 4 and 5, samples were collected of the final cooler recirculated water. These samples were 4-hour composites, equal portions being composited hourly by Bethlehem Steel Company personnel. Approximately one gallon of sample was collected. Analyses were made for the content of phenol, ammonia and cyanide. As there was no practical means available for flow measurement in this system, results are expressed in concentration units only.

The analyses of this liquor were as follows:

Date	Parts per million		
	Phenol	Cyanide as CN	Ammonia (NH_3 as N)
January 3	2210	126	1280
4	2050	131	1530
5	--	161	1740
Average	2130	139	1520

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APPENDIX B

COKE PLANT WASTES

Daily Analytical, Waste Quantity and Production Data

Coke Plant
Bethlehem Steel Co.
Lackawanna, N.Y.

Table B-5 - Tabulation of Individual Results
Concentration and Gross Quantities

(Sheet 1 of 4)

Date 1951	Flow MGD	Phenols		Cyanides as SCN		Thiocyanates as CNS		Ammonia as N		Oils		pH
		ppm	lbs	ppm	lbs	ppm	lbs	ppm	lbs	ppm	lbs	
Water Supply and Pump Station 10												
Oct. 28	20.0	< 0.01		< 0.10		< 4.0						7.5
30		.02	3.32	< .10		< 4.0						7.6
31		.12	19.9	< .10		< 4.0						7.5
Nov. 5		.16	26.6	< .10		< 4.0						7.5
6		.10	16.6	< .10		< 4.0						7.5
7		.16	26.6	< .10		< 4.0						7.5
8		.32	53.1	< .10		< 4.0						7.5
12		.24	39.8	< .10		< 4.0				26.9	4465	
13		.14	23.2	< .10		< 4.0		0.14	23.2	26.5	4399	7.3
14		.08	13.3	< .10		< 4.0		.78	129			7.3
15		.10	16.6	< .10		< 4.0		.73	121			7.4
Average		0.13	21.7	< 0.10		< 4.0		0.55	91	26.7	4432	
Ammonia Still Waste												
Oct. 28	0.180	32.3	48			299	448					
30	.184	30.1	46	22.4	34	254	389					
31	.130	25.4	27	21.6	23	298	322					
Nov. 5	.166	31.5	43	21.6	30	328	452					11.4
6	.170	23.5	33	32.1	45	351	496					11.6
7	.172	42.8	61	30.6	44	338	484					11.5
8	.146	66.1	80	34.3	42	347	421					11.4
12	.176	37.6	55			326	479					
13	.176	36.1	53			336	494					11.4
14	.164	54.9	75	23.8	32	321	440	36.9	50			11.4
15	.174	70.5	102	22.6	33	332	381	28.0	40			11.4
Average	0.167	41.0	57	26.1	35	322	448	32.4	45			

Coke Plant
Bethlehem Steel Co.
Lackawanna, N.Y.

Table B-5 (Continued)

(Sheet 2 of 4)

Date 1951	Flow MGD	Phenols ppm	Phenols lbs	Cyanides as SCN ppm	Cyanides as SCN lbs	Thiocyanates as CNS ppm	Thiocyanates as CNS lbs	Ammonia as N ppm	Ammonia as N lbs	Oils ppm	Oils lbs	pH
Ammonia Still Influent												
Nov. 12	0.176	776.	1134.									
13	.176	878	1283	39.0	57.			6060.	8852.			
14	.164	867	1180	49.9	68			5910	8045			
15	.174	878	1268	48.9	71			6010	8680			
Average	0.173	850	1216	45.9	65			5993	8526			
Cooling Water - Ammonia Liquor												
Oct. 28	12.2	<0.01		0.5	50.6	<4.0						
30	12.2	.06	6.08	.13	13.2	<4.0						
31	12.2	.10	10.1	<.10		<4.0						
Nov. 5	12.2	.24	24.3	.13	13.2							7.6
6	12.2	.34	34.4	.13	13.2							7.5
7	12.2	.80	81.0	.13	13.2							7.5
8	12.2	.88	89.1	.14	14.2							7.6
12	12.2	.12	12.2	<.10								
13	12.2	.12	12.2	<.10				0.45	45.6			7.5
14	12.2	.09	9.1	<.10				.28	28.4			7.5
15	12.2	.08	8.1	<.10				.36	36.5			7.6
Average	12.2	0.26	26.1	0.11	10.7	<4.0		0.36	36.8			7.5-7.6
Quench Water												
Nov. 14	1.02	1.5	12.7	<0.1				0.62	5.3			
15	1.02	1.6	13.6					.73	6.2			
Average	1.02		13.2					0.68	5.8			

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Coke Plant
Bethlehem Steel Co.
Lackawanna, N.Y.

Table B-5 (Continued)

(Sheet 4 of 4)

Date 1951	Flow MGD	Phenols ppm	Phenols lbs	Cyanides as SCN ppm	Cyanides as SCN lbs	Thiocyanates as CNS ppm	Thiocyanates as CNS lbs	Ammonia as N ppm	Ammonia as N lbs	Oils ppm	Oils lbs	pH
Intercepting Sump Benzol Plant												
Oct. 28	0.171	40.0	56.8	15.7	22.3	40.7	57.8					
30	.171	53.3	75.6	27.3	38.7	76.8	109.					
31	.171	48.1	68.3	26.3	37.3	75.1	107					
Nov. 5	.171	64.0	90.8	21.2	30.1	77.0	109					
6	.171	43.9	62.3	25.2	35.8	71.0	101					
7	.171	43.4	61.6	23.0	32.6	72.0	102					
8	.171	47.7	67.7	24.9	35.3	72.0	102					
Average	0.171	48.6	69.0	23.4	33.2	69.2	98					
Benzol Plant Outfall Sewer												
Oct. 28	6.68	1.0	55.4	0.10	5.54	<4.0						7.5
30	6.68	1.5	83.2	.52	28.8	<4.0						7.4
31	6.68	2.2	122.	.70	38.8	<4.0						7.5
Nov. 5	5.50	3.2	146	.70	32.0							7.4
6	5.50	1.7	77.6	.55	25.1							7.3
7	5.50	2.1	95.9	.52	23.7							7.4
8	5.50	2.25	103	.52	23.7							7.5
12	5.50	1.70	77.6	.26	11.9					34.4	1570	7.8
13	5.50	1.50	68.5	.80	36.5			1.7	77.6	31.3	1429	
A verage	5.89	1.9	92.1	0.52	25.1	<4.0		1.7	77.6	32.9	1500	
Upper Coke Plant Drain												
Nov. 14	1.49	16.	198.	2.1	45.9							
15	1.49	16	198	3.6	64.5							
Average	1.49	16	198	2.8	55.2							

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Coke Plant
Bethlehem Steel Co.
Lackawanna, N.Y.

Table B-5 (Continued) (Sheet 3 of 4)

Date 1951	Flow MGD	Phenols ppm	Phenols lbs	Cyanides as HCN ppm	Cyanides as HCN lbs	Thiocyanates as CNS ppm	Thiocyanates as CNS lbs	Ammonia as N ppm	Ammonia as N lbs	Oils ppm	Oils lbs	pH
Gas Producer Waste												
Oct. 30	0.64	7.5	39.8	1.7	9.0	<4.0						
31	.64	17.0	90.3	1.7	9.0	<4.0						
Nov. 5	.64	8.5	45.2	1.4	7.4	<4.0						
6	.64	8.5	45.2	1.3	6.9							
7	.64	11.0	58.4	1.6	8.5							
8	.64	11.0	58.4	1.5	8.0							
12	.64	8.0	42.5	2.1	11.2							
13	.64	8.5	45.2	.78	4.1							
Average	0.64	10.0	53.1	1.5	8.0	<4.0						
Main Coke Plant Drain												
Oct. 28	17.2	1.5	214	<0.10		<4.0						
30	17.2	2.0	286	.70	100.	<4.0						
31	17.2	2.0	286	.39	56	<4.0						
Nov. 5	16.9	2.0	281	.52	73							7.6
6	17.6	2.3	336	.40	58							7.5
7	18.0	2.2	329	.42	63							7.5
8	17.3	3.6	517	.39	56							7.5
12	17.2	1.7	286	.26	37			3.4	49			7.5
13	17.2	1.7	286	.21	30			4.5	64			7.5
Average	17.3	2.1	313	0.41	53	<4.0		4.0	57			7.5-7.6
Main Coke Plant Drain Above North Quench Station												
Nov. 14	16.3	2.60	353	<0.1	0			4.5	61.5			7.5
15	16.4	3.00	410	.26	35.5			5.0	68.3			7.5

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Coke Plant
Bethlehem Steel Co.
Lackawanna, N.Y.

Table B-6 - Daily Production Quantities

Date 1951	Flue Temp °F	Coking Time hours	Dry Coal Coked tons	Wet Coal Coked tons	Coke Pro-duced tons	Gas MCF	Ammonia Liquor gallons	Ammonium Sulfate pounds	Light Oil gals	Tar gals	Sodium Pheno-late gals*
Oct. 28	2479	15.4	7959	8449	5998	85.7	150,000	151,585	25,923	45,798	1406
30	2479	15.9	7529	7979	5596	82.2	153,700	150,379	23,267	45,986	0
31	2476	16.8	7265	7693	5385	81.6	108,000	146,165	25,016	54,986	0
Nov. 5	2479	15.9	7863	8323	5859	85.2	137,800	157,631	26,440	69,879	1562
6	2468	15.2	8047	8534	5953	84.8	142,100	130,275	26,054	58,916	0
7	2451	16.0	7652	8092	5644	83.6	142,960	161,509	24,891	40,679	0
8	2458	15.3	8006	8505	5964	80.9	121,900	151,074	25,361	76,611	0
12	2448	15.5	7884	8383	5840	85.4	146,800	156,951	27,235	40,973	1987
13	2476	15.6	7858	8341	5806	84.7	146,800	145,529	26,124	56,670	0
14	2469	15.6	8008	8473	5951	85.5	136,500	151,580	27,130	36,657	2309
15	2463	15.3	8024	8508	5964	84.1	144,800	151,580	26,594	36,657	0
18											1475
Average	2468	15.7	7827	8298	5815	84.0	139,215	150,387	25,821	51,256	416**

* Sp. Gr. ≡ 1.2 and phenol content ≡ 25%.

** Average of 27 days (Oct. 28 through Nov. 23).

SECTION C

CONTINOUS STRIP MILL WASTES

December 12-21, 1949

by

Charles E. Sponagle, Asst. Sanitary Engineer

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SECTION C

CONTINUOUS HOT AND COLD STRIP MILL WASTES

Description of Process

Introduction

The process consists of the rolling and processing of slabs for the production of steel strip, sheet and plate of varying dimensions and physical properties to meet the requirements of consumers. The continuous strip mill is comprised of two major divisions: (1) the hot mill department, in which steel is rolled while hot, and from which hot-rolled strip, sheet and plate is shipped to the consumers, and (2) the cold mill department, in which hot-rolled strip is further reduced in thickness by rolling in the cold state, following which the cold-rolled steel is processed and shipped.

Chief Characteristics of Plant

The continuous strip-sheet and plate mill is built on a plot of 67 acres of ground adjacent to the Lackawanna plant. The mill has an annual capacity of some 600,000 tons of strip, sheet,and light plate.

Wide strip up to 60 inches in width by 0.0625 inch gauge (thickness), and 72 inches in width by 0.078 inch gauge, with a minimum width of 18 inches by 0.05 inch gauge, can be continuously rolled in one heating in the hot mill.

Cold-rolled strip is produced in a range from 18-1/2 inches to 72 inches wide and from 0.0125 inch gauge for narrow widths up to 0.109 inch gauge. By cross-rolling in the 93-inch 4-high skin pass mill, sheets may be rolled up to 84 inches in width.

The plant has ample and co-ordinated facilities for every important form of processing strip and sheet steel as such, but not including coating processes or rolling down to tin mill gauges. All possible refinements for hot-rolled products, as well as for cold-rolled sheet and strip for which there is any commercial demand, are provided, and at the same time the mill is equipped to roll and finish light plate up to one-half inch thick.

Hot Mill Department

(a) Strip Rolling - A slab from storage is heated to rolling temperature, which is close to 2250°F, in one of four furnaces. When ready to be rolled, the heated slab leaves the furnace and proceeds down the roller table, starting out perhaps 7-1/2 feet long, 4 feet wide, and 5 inches thick. It first approaches a scale-breaking stand in front of a series of four mill stands in the roughing train. This scale-breaking stand consists of two rolls, each 24 inches in diameter and 76 inches long, through which the slab is forced and given a slight reduction in thickness, to break up any scale or oxide that may be on the outer surfaces of the slab. If the scale were not removed, it would be rolled into the strip and would seriously impair its quality. As the slab leaves the scale-breaker, water at a pressure of 1,000 pounds per square inch is sprayed upon it; this is effective in removing the loosened scale.

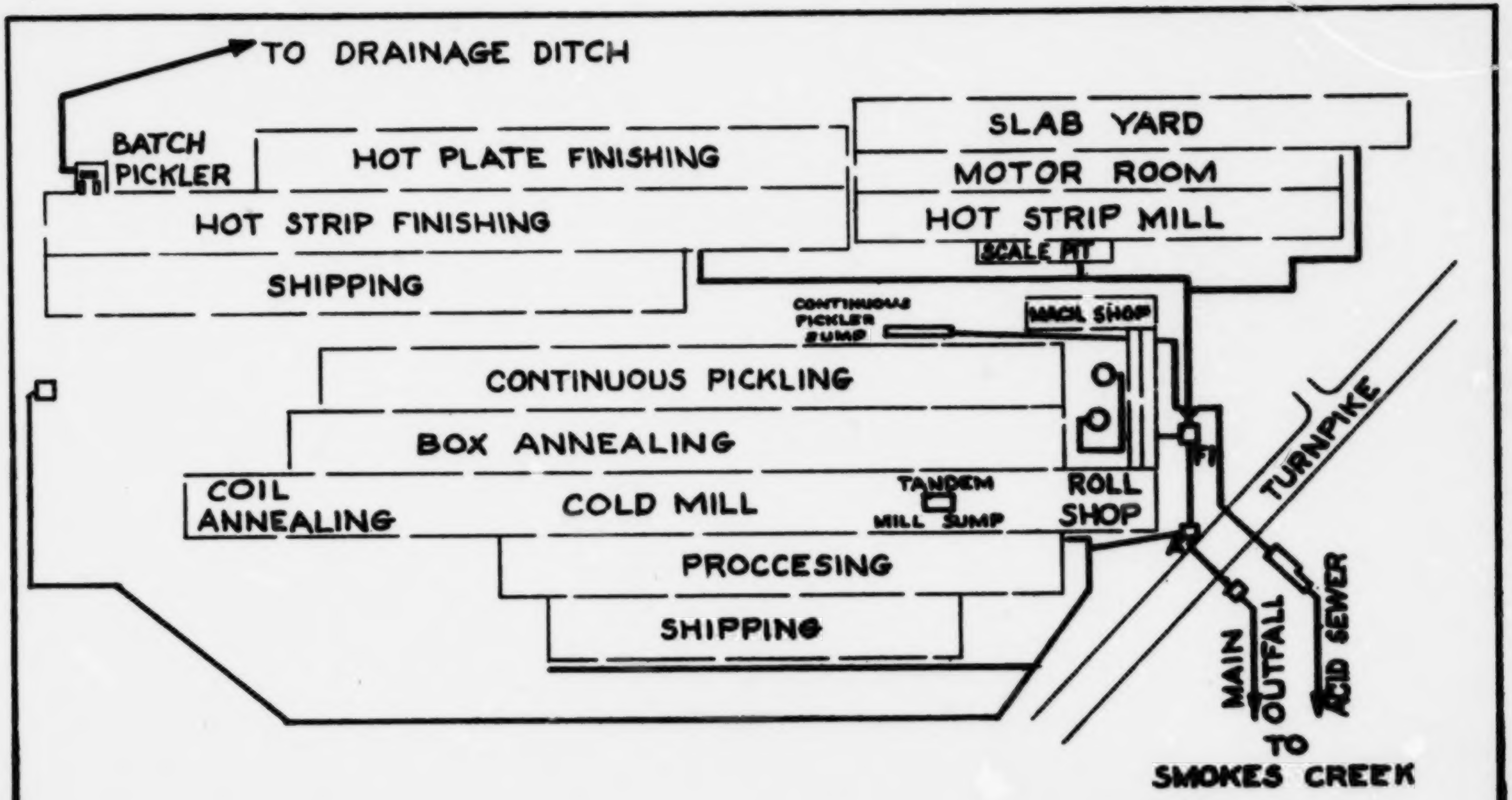
TO DRAINAGE DITCH
BATCH PICKLER
HOT PLATE FINISHING
HOT STRIP FINISHING
SHIPPING
SLAB YARD
MOTOR ROOM
HOT STRIP MILL
SCALE PIT
CONTINUOUS PICKLER SUMP
MACH. SHOP
CONTINUOUS PICKLING
BOX ANNEALING
COIL ANNEALING
COLD MILL
TANDEM MILL SUMP
ROLL SHOP
PROCCESING
SHIPPING
TURNPIKE
MAIN OUTFALL
ACID SEWER
TO SMOKES CREEK

FIGURE C1
CONTINUOUS STRIP MILL
SEWER LINES
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

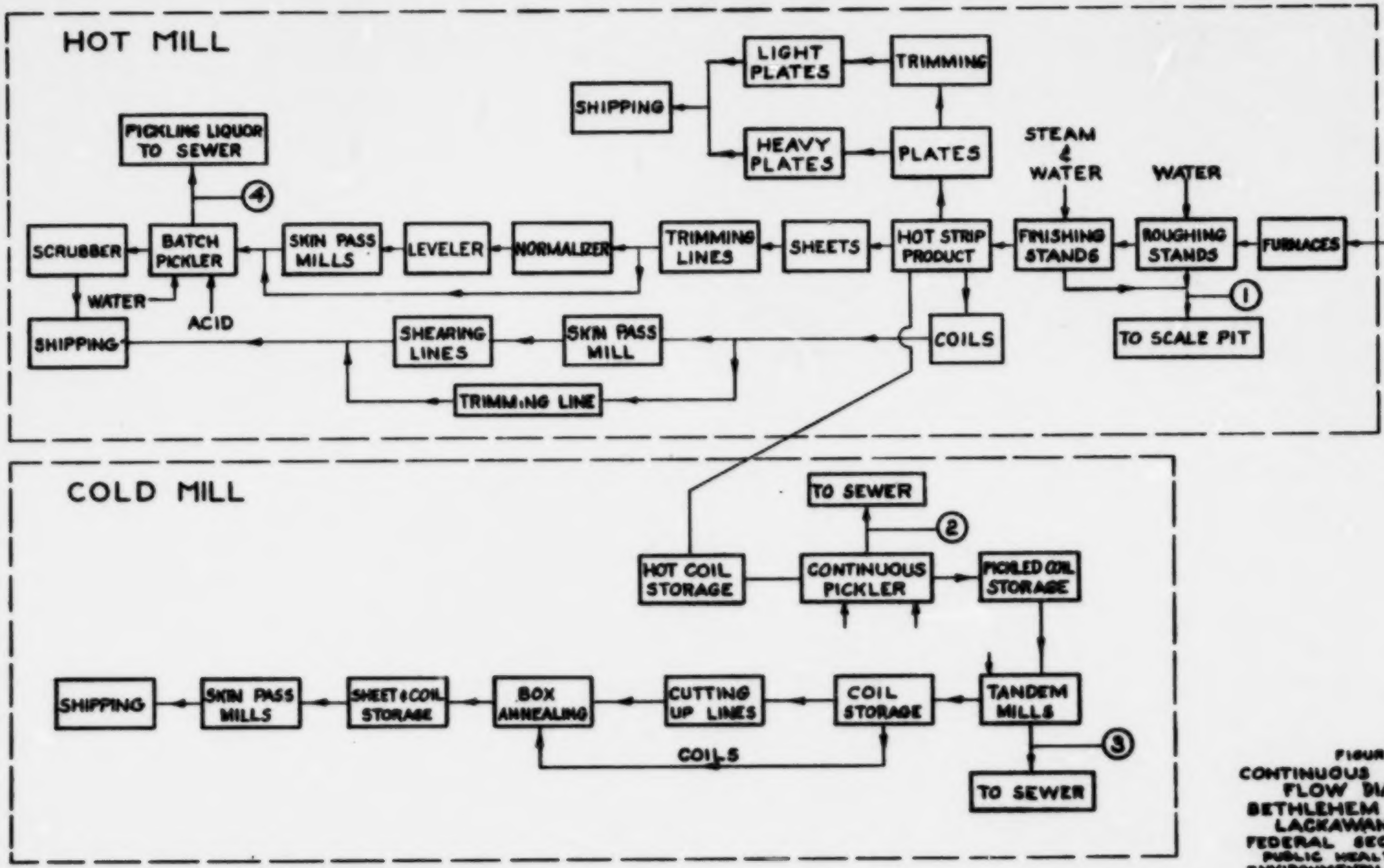
HOT MILL
SLABS FROM BLOOMING MILL
FURNACES
WATER
ROUGHING STANDS
STEAM & WATER
FINISHING STANDS
①
TO SCALE PIT
HOT STRIP PRODUCT
PLATES
TRIMMING
LIGHT PLATES
HEAVY PLATES
SHIPPING
COILS
SHEETS
TRIMMING LINES
NORMALIZER
LEVELER
SKIN PASS MILLS
BATCH PICKLER
④
PICKLING LIQUOR TO SEWER
SCRUBBER
WATER
ACID
SHIPPING
SKIN PASS MILL
SHEARING LINES
TRIMMING LINE
COLD MILL
HOT COIL STORAGE
CONTINUOUS PICKLER
②
TO SEWER
PICKLED COIL STORAGE
TANDEM MILLS
③
TO SEWER
COIL STORAGE
CUTTING UP LINES
BOX ANNEALING
COILS
SHEET & COIL STORAGE
SKIN PASS MILLS
SHIPPING

FIGURE C8
CONTINUOUS STRIP MILL
FLOW DIAGRAM
BETHLEHEM STEEL CO.
LACKAWANNA, N. Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO [illegible]

The slab is now ready for the heavy reductions it gets in the roughing mills. It first enters a 4-high broadside mill, passing between two rolls, each 36 inches in diameter and 96 inches long, backed up on top and bottom by two rollers of the same length, but 49 inches in diameter. These upper and lower rolls tend to prevent the smaller rolls, between which the slab passes, from springing or bending while being subjected to terrific pressure and the extreme heat of the slab.

Slabs which are to emerge from the finishing mill as strip-sheet not over 48 inches wide pass through this broadside mill without a halt. If, however, a strip width greater than 48 inches is to be produced, the slab is turned crosswise on a turntable and is cross-rolled from the slab width to the required strip width, after which it is turned back 90 degrees for rolling lengthwise on the remaining mill stands.

Leaving the broadside mill, the slab enters a slab squeezer, which serves to true and square its side edges before entering the remaining three mills of the roughing group. The slab squeezer not only squeezes the slab sideways, so as to insure evenness of its edges, but also exerts pressure downward, so that the slab will be of uniform thickness.

The slab now approaches mills Nos. 2, 3 and 4 of the roughing train. These mills have working rolls 24-1/2 inches in diameter and 79 inches long, and backing rolls of the same length and 49 inches in diameter. Before the slab enters the No. 2 mill, water at a pressure of 1,000 pounds per square inch is again forced on it to clean off any scale or dirt that may have accumulated since the previous reduction. This spraying is inaddition to the thorough cleansing by high-pressure water after the slab leaves the scale-breaking machine. At the No. 4 stand in the roughing train, steam is also blown on the slab to remove dirty water and scale.

The slab has now been reduced to approximately one-fifth of its original thickness, i.e., to somewhere between 5/8 and 1-1/4 inches. It next passes over a roller table about 95 feet long, leading to the finishing group of mills. Since the finishing temperature of the hot strip is a prime factor in the quality of material produced, this roller table also serves as a special temperature control table for the slab in transit between the roughing and finishing group of mills.

As the slab progresses down this roller table, the operator controls the speed of the slab movement, retarding its progress if the metal is still too hot, or, if necessary, reversing the direction of the movement for a moment or two until the temperature has dropped to the right point - between 1900° and 1950°F.

The slab now enters a second scale-breaking stand and again is subjected to a water spray at 1,000 pounds per square inch pressure to remove scale that has formed during the journey from the last roughing mill. Next, the slab passes to a flying crop shear, which cuts off its uneven ends (formed in the roughing train) which otherwise would mar the finely polished rolls of the finishing mills.

The strip then passes through six 4-high finishing stands, with inner working rolls 24-1/2 inches in diameter, outer rolls 49 inches in diameter, and all rolls 79 inches in length. At each stand the strip is reduced about one-third in thickness and greatly increased in length and may, for instance, emerge from the last finishing stand one-twentieth of an inch thick and over 1,100 feet long.

As in the roughing mills, so in the finishing mills, every precaution is taken during the rolling to eliminate scale and dirt. Here, steam instead of water is sprayed on the rapidly thinning strip just after it passes through each set of rolls. As it leaves the last finishing mill, the rapidly moving strip may be cut to any predetermined length from 8 feet up to 25 feet by a flying shear synchronized with the speed of the strip or, if the strip is to be coiled, the flying shear may be used to cut off its front end as it emerges from the mill train.

Since hot-rolled strip is manufactured singly and in great lengths, the speed at which it leaves the finishing stands must necessarily be high. The speed varies from 676 to 1,352 feet a minute, depending upon the gauge being finished - the thinner gauges necessitating the higher speed.

Hot strip to be manufactured in sheet or flat form moves down the entire length of the roller table following the last finishing stand to a sheet piler. As the sheets reach the piler, they pass through a pinch roller which imparts to each the proper tractory so that it will land in the correct position on the piler. Sheets are them picked up in piles by a sheet carrier suspended from a traveling crane, and removed to temporary storage for self-annealing.

When the strip is to be coiled, the coiler door (located on the roller table, about 300 feet beyond the last finishing stand) is raised, and the strip drops down about eight feet, where it is wound around a mandrel. An air-operated extractor pushes the coiled strip off the mandrel and leaves it lying in a container which then is tipped over 90 degrees, depositing the coil standing upright on a chain conveyor. Some of these coils are removed to temporary storage to be processed as hot-rolled strip, while the remainder travel on the conveyor through an underground tunnel about 260 feet long, to storage space in the continuous pickling room in the cold mill building.

(b) Refining Processes for Hot-Rolled Sheet and Strip - Much of the hot-rolled product is used for purposes that require it to be more workable and flatter than it generally is as it emerges from hot-rolling. In order to make strip and sheets soft and ductile so that they will be workable - that is, will undergo severe forming and bending operations without cracking or breaking - many refining processes are required.

Some hot-rolled sheets for certain purposes, however, are sold after self-annealing, which means that they have been permitted to cool off in packs while still hot from the final reduction. This improves the grain structure of the metal and is adequate for many uses of hot-rolled strip and sheet. However, if deep drawing is essential to the hot-rolled product, the steel is accordingly normalized in a furnace 150 feet long, which heats it to about 1750°F in a 75-foot zone and gradually cools it in another 75-foot zone. This is a continuous process, taking about 15 minutes for passage through both zones.

Further refining and flattening is accomplished by passing the steel through a roller leveling machine which consists of several sets of longitudinal small-diameter rolls, held in a housing and so arranged that the top and bottom layers are offset, permitting the rollers to mesh. Strains in the metal from leveling are removed by putting the steel through skin pass mills. In doing this, the gauge of the material is very slightly reduced. If a bright finish is desired for the surface of the steel, highly polished rolls are used.

Rust is removed from the sheets by batch pickling in a sulfuric acid solution (see page 120), following which the sheets are washed, dried and oiled, and enter the shipping department.

(c) Plate Rolling - If plate is being rolled, the material is sidetracked as it leaves the finishing mills and enters the plate finishing department over a roller table equipped with individually motor-driven rollers. Then a chain transfer bed, 250 feet long, serves to transfer the plate sideways to a second roller table about 700 feet long.

Traveling over the second table line, the plate passes through a roller leveler forward to an end shear, where it is reduced from mill lengths to 100-foot stock lengths, and moves forward to a 100-foot-long chain transfer bed located at the end of the table run. At this juncture, light plate (5/16" thick and under) enters a trimming line, which comprises a rotary side-trimmer, a leveler, and an up-cut shear, at the end of which it is placed in storage. Heavy plate, now in 100-foot maximum lengths, is transferred onto a third roller table, about 500 feet long, parallel to the second line, but operating in the opposite direction. At the end of the third table line are located a chain transfer and roll-offs for the removal of the plate for stocking.

The purpose of moving the plate over the long tables is to provide ample time for cooling, since, as plate is thicker, more time is required than for strip material. Plate which is not being placed into stock can be moved from the chain transfer to a fourth roller table line, again 700 feet long, in which are located a rotary side-trimming shear, a roller leveler, and an end shear, which trim, level and cut plate to exact sizes, whereupon it then passes to roll-offs and skids, preparatory to shipment.

Cold Mill Department

The most important function of cold-rolling is reduction to lighter gauge than can be economically hot-rolled. Furthermore, for many uses, strip-sheet steel must be refined beyond the stages provided by the facilities of the hot mill department. For example, such treatments include a thorough pickling to remove all impurities from the surface of the metal. To obtain the highest grade of ductility, to permit deep drawing of sheets while being formed for many purposes, and to improve the grain structure of the strip metal after going through the hot-rolling process, careful heat treatment in box-annealing furnaces is required. After this treatment has been given, the strip metal must be rolled in the skin pass mills and undergo a very slight reduction in gauge to give the thin sheets a finely polished surface and for the tempering effect.

Cold-rolled strip has a more accurate thickness and a more definite degree of hardness than can be achieved by hot-rolling, and presents a better polished, glossier surface. In particular, because of the heavy cold reduction, its elastic limit is on the average higher than that of sheets produced on the conventional hand mill, which gives it a distinct advantage when used for many types of difficult stampings.

The cold-rolling and corollary operations are carried out without backtracking, with the same continuous flow of material as in the hot mill, but so many varieties of products are processed that a description of the sequence by which each of the different qualities and finishes are arrived at would make a voluminous article in itself. Only the main operations can here be described.

(a) Pickling - Hot-rolled coils intended for the refinements of the cold mill processes are picked up from storage in the continuous pickling building by an overhead magnet and deposited upon a coil upender, which lays the coil down flat. The strip passes first through an uncoiler and a roller leveler, and then comes to a shear which cuts the front and rear ends off even. The front of the coil is then welded to the end of the preceding coil which has already started through the pickling process. Following trimming of the weld, the strip goes through a "looping pit" immediately preceding the continuous pickling vats. The looping operation provides for slack in the coil and allows time for welding and trimming so that there will be no interruption of the continuous movement of the metal through the picklers.

Each pickler consists of seven tanks, the first five of which contain a solution of sulfuric acid to clean the metal. The last two tanks contain water for rinsing the acid from the strip (see page 122). There is a continuous flow of acid solution, water and steel in this process, the steel and liquids moving countercurrently. As the strip emerges from the last tank, it moves over a roller table under which is a hot-air drier, designed to remove all traces of moisture before the strip enters the pinch-roll which has been pulling it through the entire pickling process. Next, the welds are cut out and the strip passes through an oiling machine and recoiling apparatus, following which it is ejected onto a gravity conveyor and travels to a storage space adjacent to the tandem cold-rolling mills.

The pickling operation must be performed carefully. All impurities must be removed from the surface of the metal, but the acid must not be allowed to pit the surface or the finish will be ruined in the subsequent cold-rolling.

(b) Cold-Rolling in Tandem Mills - The next step after pickling is to reduce the strip's thickness to such gauges as may have been ordered by customers. This is accomplished by rolling the metal cold in one of two tandem trains, each train comprising three stands of 4-high mills, such as are used in the hot mill. One set of mills is designed to roll coils up to 48-inch maximum width, while the other will roll them up to a maximum width of 72 inches.

Since the strip is now cold, much more force must be exerted to obtain the customary reduction of about 60 per cent which it receives as it passes through the train of three mills. The tandem arrangement of these mills in series makes possible three cumulative reductions in one pass of the strip through the mill train. Synchronizing the series of mills to the proper speed and reduction is accomplished by an elaborate electrical control system.

As the strip leaves the last stand of the cold mills, it is recoiled on a coiling reel having a collapsible core, which is put under a predetermined tension to keep the strip taut during rolling and recoiling. When the strip is coiled, the reel is stopped, a pneumatic pusher discharges the coil from the reel onto a transfer buggy, and it is then taken away for subsequent treatment.

The two tandem mill trains have a combined capacity of about 60,000 tons a month. They are capable of producing cold-rolled strip in a range from 18-1/2 inches to 72 inches wide, and from 0.0125 inch gauge for narrow widths up to 0.109 inch gauge.

(c) Box Annealing - While the strip is now reduced to the specified gauge, it still lacks forming quality, ductility, and amenability to deep drawing processes. To secure these qualities, it must receive heat treatment at high temperatures, the exact degree of which is determined by the use to which the customer desires to put the product.

The annealing process is one of the most vital and critical operations employed in the manufacture of high quality, deep-drawing strip sheets. It must be so carried out that the strip retains its bright surface and does not become oxidized or scaled.

Preparatory to annealing the strip, the coils from the cold mill are prepared in either sheet or strip form. If in sheet form, the coils are taken to a combination cutting-up line consisting of a feed reel, side-trimming shear, roller leveler and a flying shear, arranged in tandem. The end of the coil is fed into the trimmer, which trims the edge of the strip to the specified width; then through the leveler and flying shear, which flattens the strip and shears it to the required length for delivery in packs to the annealing department. Strip to be annealed in coil form is taken to a loose-winding machine which is designed to unwind the tightly coiled strip as it comes from the tension reel at the tandem mill and rewind it loosely. This is done to permit a more thorough annealing and to eliminate the possibility of the smooth surfaces of the coils adhering to each other under the annealing temperatures.

The annealing equipment consists of 26 furnaces that will accommodate sheets up to 75 inches in width by 220 inches long, or coils up to 59 inches in width; and four furnaces capable of taking sheets up to 84 inches wide by 186 inches long, or coils up to 72 inches in width. An annealing unit consists of a furnace, together with four bases or bottoms, and inner covers. The furnace has the form of a rectangular steel hood lined throughout with brick, the length and width of which are but slightly greater than the corresponding dimensions of the largest sheet to be annealed. Inside and along each side are heating units in the shape of hairpin tubes, in which a mixture of blast furnace and coke oven gas is burned. The heat generated is transmitted through the inner cover over the pile of sheets. The inner cover is dome-shaped, made of steel and built of a size that will cover the pile of sheets to be annealed. The bases or bottoms are a flat brick area encased in a steel frame somewhat greater in width and length than the furnace.

In the sequence of operation, sheets or coils are piled on a base, the inner cover is placed over a pile, and the furnace is lowered over this cover and sealed with sand around its lower edge. Temperature in the furnace is raised as rapidly as practicable until it rises a little above the predetermined annealing temperature. To obtain this result requires from thirty to forty hours for sheets and about twenty hours for coils. The furnace temperature is then maintained at this level by automatic control. Packs of sheets are soaked for about 22 hours at this temperature, coils about 28 hours. At the end of this time the furnace is removed by an overhead crane to an adjoining base which is piled with steel in a manner similar to the first. The annealed pile, enclosed in its inner cover, is allowed to stand until the sheets are cooled to about 200°F. The inner cover is then removed, and when the pile is cooled to atmospheric temperature, it is taken away for the next operation. This cycle of operations is continued for each base and repeated when a base becomes empty.

(d) Tempering in Skin Mills - The annealed sheet is in its softest and most ductile state so that it is suitable for deep drawing operation. Because of this extreme softness, it has a tendency to stretcher-strain. To eliminate this tendency, both sheets and coils are given a slight reduction of one to three per cent in tempering or skin mills.

For this purpose, there are installed two 4-high mills with working rolls 20 inches in diameter by 75 inches long and backing rolls 49 inches in diameter; one 4-high mill with working rolls 24 inches in diameter and 93 inches long; and one 2-high mill with rolls 28 inches in diameter, 55 inches long. All of these mills will skin-roll sheets singly, and one of the 4-high,25 inch mills, together with the 2-high, 55 inch mill, are equipped with feed and tension reels for tempering strip in coil form.

The slight gauge reduction of one to three per cent taken by the steel in these mills affects the hardness and ductility of the metal, and smooths and polishes its surface. These qualities can be modified over a wide range by varying the amount of reduction within the range indicated. The exact per cent reduction is governed by the draw required in the sheet for the purpose intended.

(e) Final Processing and Shipping - The tempered strip is delivered to the processing building for the final operations preparatory to shipping. For plain flat material, sheets are given a pass through a roller leveler, thus flattening all irregularities in the sheet. Sheets thus leveled are flat enough for ordinary purposes. To get the sheet perfectly flat, it is necessary to stretcher-level it.

This operation is carried out by a hydraulic device known as a stretcher machine, which stretches the sheet to a point approaching the elastic limit. In this process, sheets are gripped on each end by jaws which are then forced apart slowly by hydraulic pressure. This process takes up all slack which may exist in the form of waves or buckles, and continues until the sheet is stretched taut and lies in practically a flat plane. The sheet takes a permanent set in this flat condition. It is then sheared to exact size on resquaring shears.

Some sheets are oiled to prevent them from rusting in transit, and for this work independent oiling machines are provided.

Strip in coil form can be delivered in widths ranging from one inch to 72 inches, in thickness varying from 0.0125 to 0.125 inch. To supply the narrow widths of 18 inches and under, hot or cold strip is rolled to a multiple of the desired narrow widths. The wide strip is slit on a slitting machine into several strands and rewound on a machine especially designed for this purpose. This slitting machine is also used for trimming wide strip to accurate width if desired.

In preparing the bundles of sheets or coils for shipment, they must be handled carefully and kept free from dirt. Each coil or bundle of sheets is wrapped in weatherproof paper, strapped with metal bands, and when loaded in railroad cars or trucks, is properly braced to make certain the material will be delivered in good condition. Care is also taken to arrange the load to suit the unloading and handling facilities at the customer's plant. In the case of export shipment, the wrapping of bundles is made air-tight to prevent salt-air corrosion.

Principal Wastes

Principal liquid wastes were found to result from the following operations:

1. Rolling of hot strip product
2. Cold-rolling in tandem mills
3. Batch pickling of hot-rolled sheets
4. Continuous pickling of hot-rolled coils.

These wastes will be taken up in the above order, and the sources and major characteristics of each waste will be noted at this point.

Rolling of Hot Strip Product - Scale Pit Waste

A description of hot-rolling of steel in this mill has already been given (page 104). Liquid wastes in this operation arise from removal of scale and dirt from the strip by both water and steam washes during rolling.

A detailed diagram of the entire system appears in Fig. C-3. Cooling of the steel after leaving the furnace, and during the rolling operation, results in the production of a surface oxide, or "mill scale," on the steel. This scale is removed by the water and steam washes, and the entire volume of waste flows into the scale

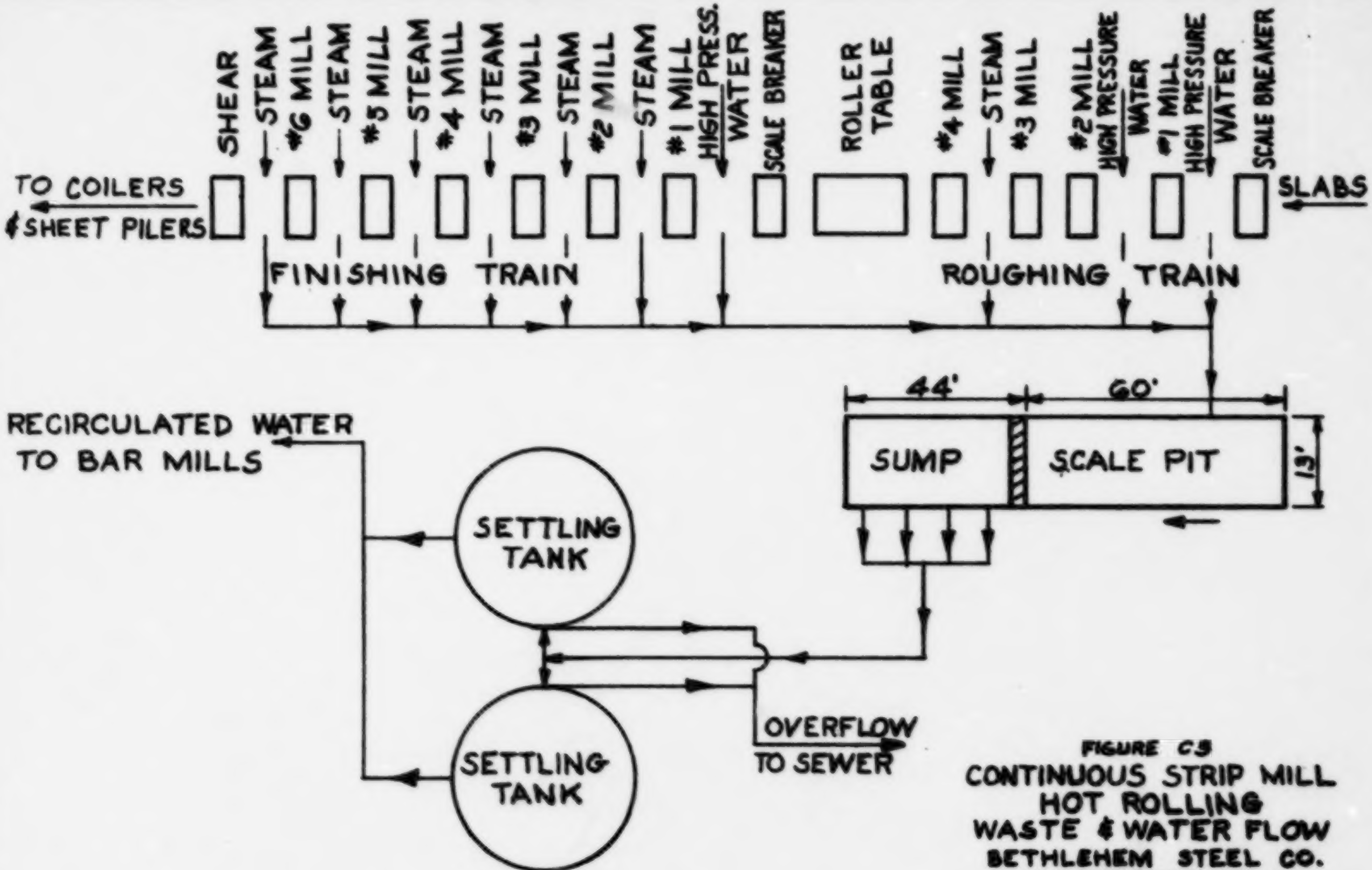
TO COILERS
& SHEET PILERS
SHEAR
STEAM
#6 MILL
STEAM
#5 MILL
STEAM
#4 MILL
STEAM
#3 MILL
STEAM
#2 MILL
STEAM
#1 MILL
HIGH PRESS. WATER
SCALE BREAKER
ROLLER TABLE
#4 MILL
STEAM
#3 MILL
#2 MILL
HIGH PRESSURE WATER
#1 MILL
HIGH PRESSURE WATER
SCALE BREAKER
SLABS
FINISHING TRAIN
ROUGHING TRAIN
44'
60'
13'
SUMP
SCALE PIT
RECIRCULATED WATER
TO BAR MILLS
SETTLING TANK
SETTLING TANK
OVERFLOW
TO SEWER

FIGURE C3
CONTINUOUS STRIP MILL
HOT ROLLING
WASTE & WATER FLOW
BETHLEHEM STEEL CO.
LACKAWANNA, N. Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

pit. In this pit, which is nothing more nor less than a settling basin, the larger particles of scale settle and are recovered by dredging which is carried out daily.

The waste containing both soluble iron and such suspended iron as not settled, flows by gravity into a sump. Four centrifugal pumps convey the liquid to two circular settling tanks for further removal of suspended iron by an additional period of sedimentation. Effluent from these latter units is pumped to the bar mill for use as process water. Sludge collected is discharged to the sewer at hourly intervals by opening a valve in the bottom of the tank and allowing the sludge to flow into the sewer, about 5 to 10 minutes being required for this operation.

All of the liquid pumped from the scale pit to the settling units does not pass through these units. There is an overflow provided at entrance to each tank, by means of which, scale pit effluent finds its way directly to the sewer. Since the amount of water recirculated to the bar mill is less than the total coming from the scale pit, these overflows prevent a build-up of liquid in the settling tanks and eventual flooding of the area.

Cold-Rolling in Tandem Mills - Tandem Mill Sump Waste

The tandem mills, as previously described (page 112), are located in the cold mill and serve to affect a further reduction in gauge of hot-rolled, pickled strip, by cold-rolling.

As the strip goes through these mills, the oil with which it was coated subsequent to pickling is removed. This is accomplished by emulsifying the oil with a wetting agent, and washing the strip with water. The oil-water emulsion drops into pits below the mills and is pumped into the sewer, together with cooling water from motor-generator sets, skin mills, and oil coolers (see Figure C-4).

Batch Pickling of Hot-Rolled Sheets

The pickling apparatus (see Figure C-5) consists of three concrete tanks and a centrally-located 4-arm hydraulic device for transferring steel from one tank to the other. Suspended from each arm of this device is a tray which holds from 4 to 5 tons of steel, when loaded.

Sheets to be pickled are transferred from storage and loaded into an empty tray, from which pickled sheets have just been removed. When the tray is loaded, the central column is raised by hydraulic pressure, lifting all four trays to a level above the top of the pickling tanks. The column is then rotated through one-quarter of a turn. The fresh sheets to be pickled are then above tank No. 1, the tray that was previously in tank No. 1 is above tank No. 2, etc. The column is lowered, immersing trays and sheets into the contents of the tanks. The steel that had just been removed from tank No. 3 has been pickled, and this is removed from its tray, the empty tray then being reloaded with fresh steel. While this unloading and loading is taking place, the central column is oscillating vertically, thus agitating the solution in each of the pickling tanks in order to obtain even and complete pickling. The complete pickling cycle, i.e., from loading of sheet onto a tray to removal of sheet from that tray, takes from 6 to 10 minutes.

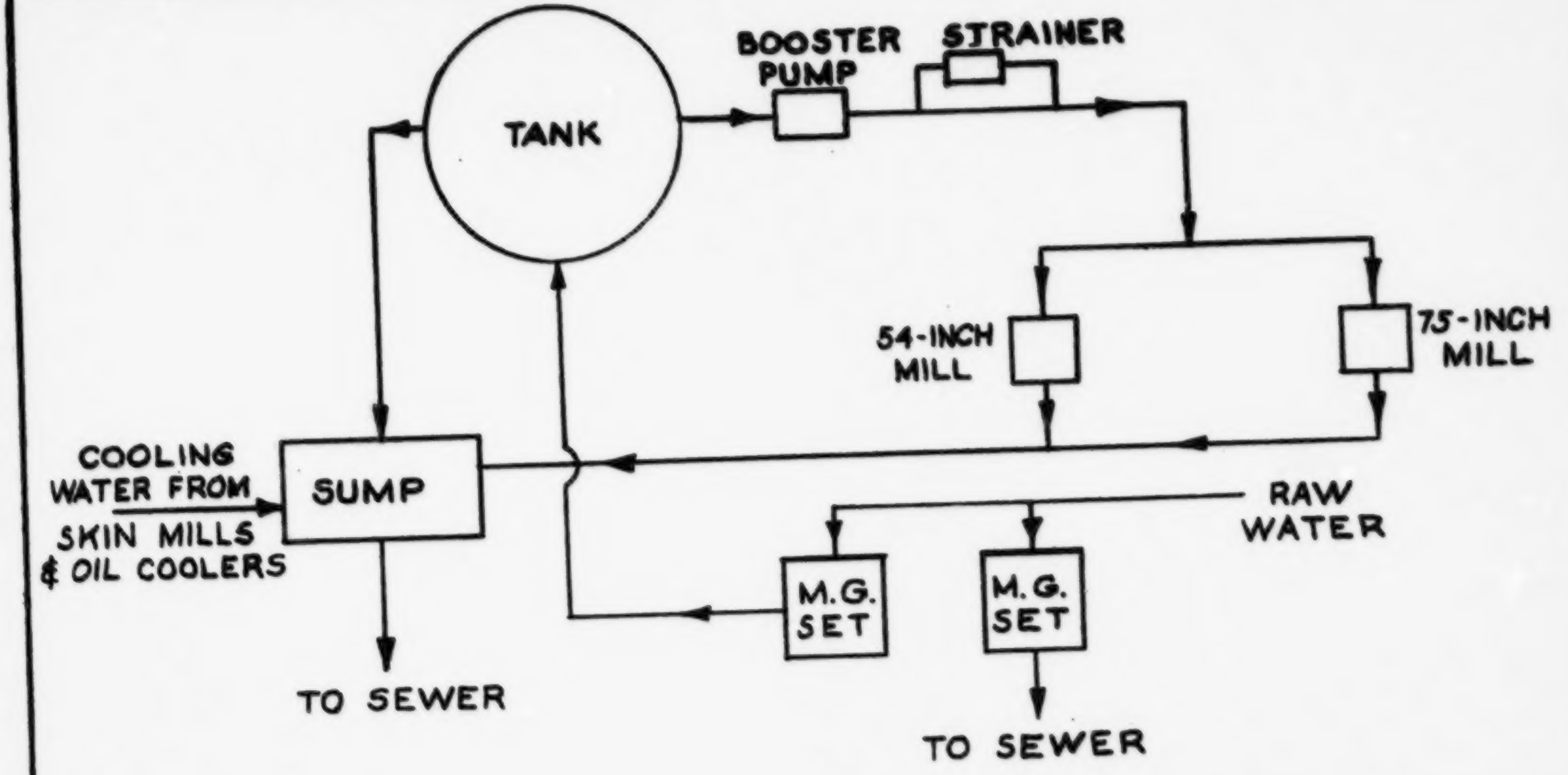
BOOSTER PUMP
STRAINER
TANK
54-INCH MILL
75-INCH MILL
COOLING WATER FROM SKIN MILLS & OIL COOLERS
SUMP
RAW WATER
M.G. SET
M.G. SET
TO SEWER
TO SEWER

FIGURE C4
CONTINUOUS STRIP MILL
TANDEM MILL SUMP
BETHLEHEM STEEL CO.
LACKAWANNA, N. Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

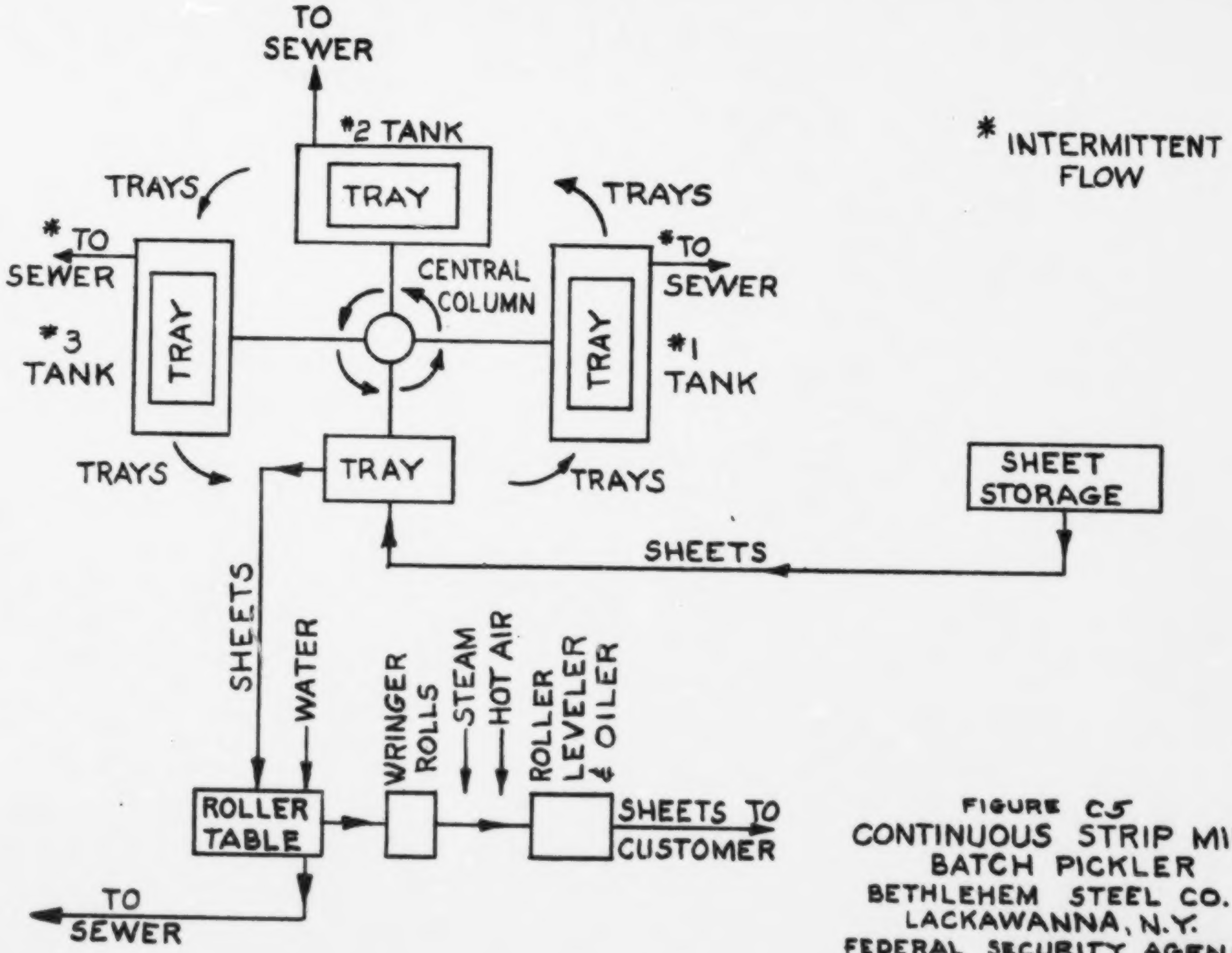
TO SEWER
*2 TANK
TRAY
TRAYS
TRAYS
* TO SEWER
*TO SEWER
CENTRAL COLUMN
*3 TANK
TRAY
TRAY
*1 TANK
TRAYS
TRAY
TRAYS
SHEET STORAGE
SHEETS
SHEETS
WATER
WRINGER ROLLS
STEAM
HOT AIR
ROLLER LEVELER & OILER
ROLLER TABLE
SHEETS TO CUSTOMER
TO SEWER
* INTERMITTENT FLOW

FIGURE C5
CONTINUOUS STRIP MILL
BATCH PICKLER
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

The first tank contains, when first filled, a solution of water and sulfuric acid. Tank No. 2 contains a weaker solution of acid, while tank No. 3 contains cold water and lime. Steel when immersed in the acid solutions, which are kept at a temperature of about 180°F, is cleaned by the action of the hot acid. The cleaning operation proper takes place in the first two tanks. The water bath in the third tank washes the acid from the steel, lime being added in this tank for neutralization of excess acid and to prevent staining of the steel surface en route to the scrubbers.

When pickling is completed, the steel is conveyed to the scrubbing line, where it receives a final wash with water and is then dried and oiled for shipment.

The tanks are dumped intermittently by removal of a lead plug in the bottom of each. No. 1 tank is dumped on an average of once daily, No. 2 tank and No. 3 tank being dumped weekly, either on Saturday night or Sunday morning.

From the scrubbing line there is a continuous flow of water to the sewer. At times slight amounts of acid that may carry over from the pickling vats will be discharged, but the presence of acid in the flow will be intermittent. This water, consequently, may be disregarded as a waste source.

Continuous Pickling of Hot-Rolled Coils

Hot-rolled coils are pickled, prior to further processing, in either one of two continuous pickling lines. A detailed diagram of one of these lines is given in Figure C-6, both lines being identical.

A continuous strip of steel enters No. 1 tank and flows in the direction shown. Sulfuric acid added as shown in No. 4 tank cleans the steel in its passage through the pickler. Steam added to tanks 1 through 5, and also to the hot water tank, maintains temperatures in these tanks of 180°-190°F. The first four tanks are pickling tanks; in No. 5 tank a beginning is made of removal of acid from the strip by running water. In the cold and hot tanks, all acid is removed from the strip by washes in cold and hot water, respectively. After leaving the pickler, the strip is dried, oiled, recoiled, and stored for further cold working.

Wastes from these picklers comprise: effluent from the hot wash tank, effluent from the cold wash tank, and effluent from the No. 1 tank, this latter being a spent acid solution. Flow of all these wastes is continuous, and all wastes are combined in one sewer prior to discharge into a sump, from which they are pumped into an acid-resistant sewer and flow into Smoke's Creek.

Survey Procedures

Sample Collection

The following samples were obtained:

1. Raw water - mill intake line.
2. Scale pit effluent - cock on pump (Pt. 1, Fig. 11).
3. Effluent from the tandem mills sump - cock on pump (Pt. 3, Fig. 11).
4. Effluent from the continuous pickler - sump (Pt. 2, Fig. 11).
5. Efflnent from the batch pickler tank (Pt. 4, Fig. 11).
6. Combined wastes from both hot and cold mills - manhole (Pt. A, Fig. 10).

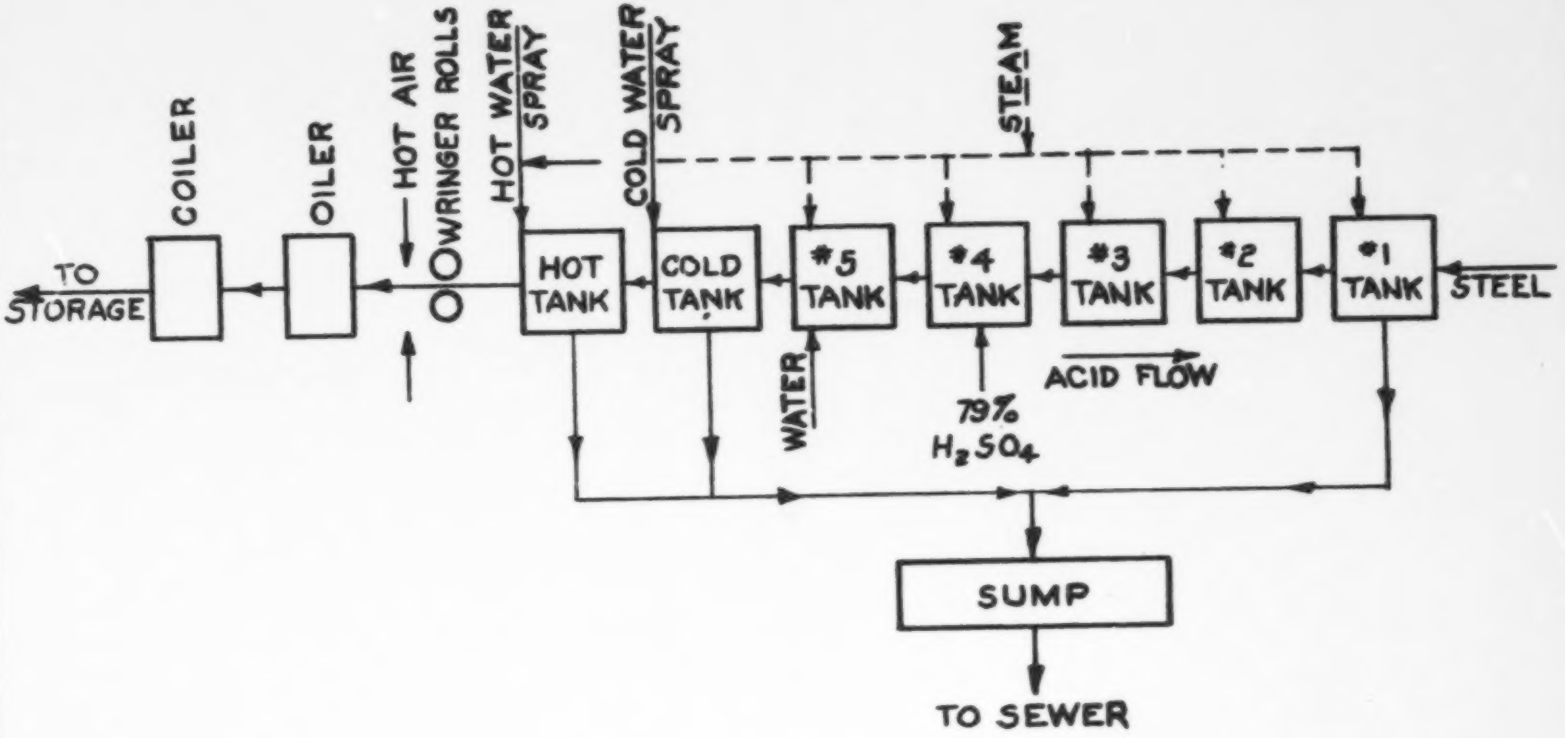
STEEL
#1 TANK
#2 TANK
#3 TANK
#4 TANK
#5 TANK
COLD TANK
HOT TANK
STEAM
COLD WATER SPRAY
HOT WATER SPRAY
WATER
79% H₂SO₄
ACID FLOW
WRINGER ROLLS
HOT AIR
OILER
COILER
TO STORAGE
SUMP
TO SEWER

FIGURE C6
CONTINUOUS STRIP MILL
CONTINUOUS PICKLER
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

All sampling was done by Bethlehem Steel Company personnel. Sampling at each point (with the exception of batch pickler effluent) extended over an 8-hour period, each sample consisting of one-quart portions collected and composited half-hourly during this time. Equal portions were taken, since there was no method available for measuring flows continuously, and also since flows were reasonably constant throughout the sampling period.

Separate samples of approximately one liter were collected for oil analysis. Each sample was a composite of the same type as was described above, only each portion consisted of 125 ml. of sample.

Samples were obtained from the batch pickler immediately prior to each tank dump. One gallon of sample was taken,and analyses run of this.

Flow Measurements

It was necessary that the following flows be established:

1. Overflow from settling tanks following scale pit.
2. Effluent from tandem mill sump.
3. Effluent from continuous pickler.
4. Effluent from each dump of batch pickler.
5. Total waste discharge from continuous mill.

While daily flow measurements were recognized as being most desirable, it was not practical to secure them. Lack of sufficient time during the day, combined with severe weather conditions, limited the number of flow determinations that were practically possible.

The methods of measurement were as follows:

1. Overflow from settling tanks following scale pit was measured by Pitot tube readings at the point where the sewer carrying these wastes discharged in the main hot mill sewer. Location is at point F1, Fig. 10.

2. The effluent from the tandem mill sump was measured by shutting off all discharge pumps and noting the time required for the liquid level to rise a certain distance in the sump. Knowing the sump dimensions, the discharge was easily calculated.

3. The effluent from the continuous pickler was measured in a manner similar to that used for the tandem mill sump.

4. Volume of waste discharged from the tanks of the batch pickler was obtained by noting the distance from the top of the tank to the surface of the liquid immediately prior to dumping. Knowing the tank dimensions, a simple computation gave the amount of waste discharged.

5. Total waste discharge from the continuous hot and cold mills was measured at the point where the main sewer from the mills emptied into Smokes Creek. Pitot tube readings were taken to establish the volume of this flow.

Laboratory Procedures

The following determinations were made on the samples collected:

Total solids, total and volatile
Suspended solids, total and volatile
Total iron
Suspended iron (mill scale)
Alkalinity or acidity
Oil
pH
5-day B.O.D.

The above is a complete list of the tests run during this survey. However, all of the above tests were not run on each sample collected. The type of analyses to which a particular sample was subjected depended upon the characteristics of the waste involved.

In general, the procedures followed were as given in "Standard Methods for the Examination of Water and Sewage," 9th edition.

Procedures for total iron, suspended iron and oil did not follow those of the foregoing reference. These modified procedures will be found in the appendix at the end of the report.

Explanation of Analyses

A brief explanation of the significance of the various laboratory determinations is given in the main appendix at the end of the report, and is intended to serve as an aid in the interpretation of the analytical results reported.

Results

Tables containing daily analytical results of each waste will be found in Appendix C.

Rolling and finishing operations in the plant are essentially constant during each day of operation.

The following table of production is given as an aid in the interpretation of the analytical results:

			Tonnage Steel Pickled		
Date 1949	Tonnage Steel Hot-Rolled	Tonnage Steel Cold-Rolled	Continuous Pickler	Date 1949	Batch Pickler
12/13	4404	2857	2525	12/13	1087
12/14	4496	2462	2323	12/14	1091
12/15	4322	2405	2506	12/15	456
12/16	3888	3197	2808	12/16	491
				12/17	649
12/19	4280	2583	2413	12/19	1223
12/20	4524	2219	2426	12/20	656
				12/21	399
Average	4319	2621	2500	Average	757

The results of the analyses and the amounts of each constituent of the waste are discussed below. Throughout the following discussion, it should be borne in mind that both picklers discharge separately from the plant, i.e., they do not discharge into the main outfall sewer. Wastes from the scale pit and tandem mill sump both discharge into the main outfall sewer.

All flows were found to be reasonably constant during the survey.

The additional flow in the main outfall (over and above that coming from the scale pit and tandem mill sump) amounted to an average of 4.6 M.G.D. The difference is attributable to cooling water, floor drainage, drinking fountains, lavatories, etc.

Discharge from the scale pit appears under two headings, namely: "Total" and "To Sewer." The designation "Total" refers to the entire volume of waste pumped from the scale pit to the recirculation system.

Of this total, an average of 9.3 M.G.D. (73%) was recirculated to the bar mill. This left 3.4 M.G.D. (or 27% of the total flow) discharging directly to the sewer from the scale pit.

Discharge from the batch pickler was on an intermittent or "dump" basis. Quantities discharged at each dump were:

No. 1 tank (average 8 dumps)	4600	gallons
No. 2 tank (1 dump)	4400	"
No. 3 tank (1 dump)	4700	"

The most important findings of the survey are compiled in the tables presented in this section. Table C-1 shows concentrations of significant constituents of the wastes, while Table C-2 contains data as to the total daily discharge of each constituent from the plant. Since the raw water used in the process contained some of these constituents, deduction of the quantities present in the raw water was necessary in order to arrive at a measure of the amount of each actually produced by plant operations. This "net discharge" of constituents appears in Table C-3.

Gross Discharge of Constituents - Table C-2

Scale pit wastes contained the following proportions of constituents discharged in the main outfall: 28% of the total solids, 31% of the suspended solids, 68% of the total iron. Of the total oil discharged, 7.3% came from the scale pit and 63% from the tandem mill sump.

Suspended solids were found to be 36% of the total solids discharged from the main outfall. Solids discharged from the picklers were found to be practically all dissolved. Iron discharged in the waste pickle liquors was all in the dissolved state. See page [illegible]

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Strip Mill
Bethlehem Steel Co.
Lackawanna, N.Y.
December 1949

TABLE C-2 - GROSS QUANTITIES OF SIGNIFICANT CONSTITUENTS

Discharged Daily from Plant

	Flow	Total Solids		Susp. Solids		Iron as Fe		5-Day BOD	Oil
		Total	Volatile	Total	Volatile	Total	Susp.		
Scale Pit	MGD	lb.	lb.	lb.	lb.	lb.	lb.	lb.	Gal.
Total Discharge	12.7	45,400	13,600	18,200	2580	8900	8300	-	292
To Sewer	3.4	12,200	3,600	4,900	700	2380	2200	-	79
Tandem Mill Sump	3.6	-	-	-	-	-	-	2500	680
Main Outfall	11.6	43,900	17,100	15,900	7600	2710	2440	4180	1080
Continuous Pickler	0.65	164,000	112,000	790	642	34,900	-	-	-
* Batch Pickler	0.0046	12,800	7.700	9.9	5.1	3260	-	-	-

* Per Dump of No. 1 Tank

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Net Discharge of Constituents - Table C-3

Of the total amount of waste constituents produced by plant operations, the scale pit effluent contributed the following: 25% of the total solids, 32% of the suspended solids, 100% of the iron. The slight difference between the amount of iron coming from the scale pit and the total amount produced by plant operations, is well within the limits of accuracy of sampling and flow measurements.

The total amount of iron lost from the plant daily in the scale pit discharge amounted to 0.097% of the tonnage hot-rolled. Iron losses from the picklers were much greater, being 0.70% of the tonnage pickled in the continuous pickler and 0.36% of the tonnage pickled in the batch pickler.

Considering net quantities as given in Table C-3, it is noted that total net suspended solids exceed net total solids slightly. The difference is likely due to small sampling and analytical errors and to the difficulties in obtaining exact solids figures in samples containing oil. The fact that these two values are quite close indicates that practically all solids contributed by mill operations were in the suspended state.

A discrepancy is apparent in the volatile total solids and volatile suspended solids figures for certain wastes given in Table C-3. Obviously it is impossible for there to be more volatile suspended solids than volatile total solids. The discrepancy is probably accounted for by the difficulty in obtaining exact figures for solids in samples containing oil.

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Strip Mill
Bethlehem Steel
Lackawanna, N. Y.
December 1949

TABLE C-3 NET QUANTITIES OF SIGNIFICANT CONSTITUENTS

Produced Daily by Plant Operations

	Flow	Total Solids		Susp. Solids		Iron as Fe		5-Day BOD	Oil
	MGD	Total	Volatile	Total	Volatile	Total	Susp.		
Scale Pit		lb.	lb.	lb.	lb.	lb.	lb.	lb.	Gal.
Total Discharge	12.7	13,300	0	13,500	1050	8200	7700	-	205
To Sewer	3.4	3,600	0	3,700	290	2190	2050	-	56
Tandem Mill Sump	3.6	-	-	-	-	-	-	2140	660
Main Outfall	11.6	14,600	4,200	11,700	6200	2060	1870	3020	1000
Continuous Pickler	0.65	162,000	111,000	560	560	34,900	-	-	-
*Batch Pickler	0.0046	12,700	7,700	8.2	4.5	3,260	-	-	-

* Per Dump of No.1 Tank

With regard to oil losses from plant activities, 66% of the total came from the tandem mill sump, 5.6% from the scale pit. Company inventories extending over a year's period show that, on the average, 257 gallons daily of make-up lubricating oil are added in the hot mill system. Analyses show that 205 gallons of oil were lost in the scale pit effluent. In the cold mill, similar records show an average daily addition of 77 gallons of make-up lubricating oil. In addition to this amount, there were during the survey 570 gallons of process oil used daily for oiling the strip following the continuous pickler, all of which is presumably removed during cold-rolling in the tandem mills. Total oil usage in the cold mill, based on inventories, thus comes to 647 gallons per day. Analyses of the tandem mill sump effluent show a daily oil loss of 660 gallons.

The tandem mill sump waste contributed a substantial portion (71%) of the total amount of 5-day B.O.D. produced by plant operations.

Summary

On the basis of the analytical data and supporting information presented in this report, certain pertinent points may be summarized as follows:

(a) Total quantities of significant wastes discharged daily from the main outfall of the continuous hot and cold strip mill were found to be:

Constituent	Present in Effluent	Present in Intake Water	Resulting from Plant Operation
Total solids	43,900 lbs	29,500 lbs	14,600 lbs
Suspended solids	15,900 "	4,200 "	11,700 "
Total iron as Fe	2,710 "	650 "	2,060 "
Oil	1,080 gals	80 gals	1,000 gals
5-day B.O.D.	4,180 lbs	1,160 lbs	3,020 lbs

(b) Total quantities of significant wastes discharged daily from the continuous pickler were found to be:

Constituent	Present in Effluent	Present in Intake Water	Resulting from Plant Operation
Total solids	164,000 lbs	2,000 lbs	162,000 lbs
Suspended solids	790 "	230 "	560 "
Total iron as Fe	34,900 "	36 "	34,900 "
Iron as $FeSO_4$	1.8% (by weight)	-	1.8% (by weight)
Acid as H_2SO_4	0.98% "	-	0.98% "

(c) Total quantities of significant wastes discharged in one dump of the No. 1 tank of the batch pickler were:

Constituent	Present in Effluent	Present in Intake Water	Resulting from Plant Operation
Total solids	12,800 lbs	100 lbs	12,700 lbs
Suspended solids	9.9 "	1.7 "	8.2 "
Iron as Fe	3,260 "	-	3,260 "
Iron as $FeSO_4$	23.1% (by weight)	-	23.1% (by weight)
Acid as H_2SO_4	7.6% "	-	7.6% "

(d) The average daily discharge from the scale pit was 12.7 M.G.D., of which 3.4 M.G.D. entered the main outfall sewer. Average discharge from the tandem mill sump was 3.6 M.G.D. The average daily discharge from the main outfall sewer was 11.6 M.G.D.

Average daily discharge from the continuous pickler was 0.65 M.G.D.

The average discharge per dump of the No. 1 tank of the batch pickler was 4600 gallons.

(e) Unit values for waste flows were as follows:

Per ton steel rolled	
Scale pit	2940 gals
Tandem mill	1370 "

Per ton steel pickled	
Continuous pickler	260 gals
Batch pickler	6.1 "

(f) Unit values for wastes produced by plant operations were:

Per ton steel rolled - hot plus cold rolling	
Total solids	2.1 lbs
Suspended solids	1.7 "
5-day B.O.D.	0.44 "

Per ton steel hot-rolled	
Iron as Fe	1.9 lbs
Oil	0.048 gal

Per ton steel cold-rolled	
Oil	0.25 gal
5-day B.O.D.	0.82 lb

Per ton steel continuously pickled

Total solids	65	lbs
Suspended solids	0.22	"
Iron as Fe	14	"
Acid	1.5	gals 60° Be H_2SO_4

Per ton steel batch pickled

Total solids	17	lbs
Suspended solids	0.01	"
Iron as Fe	4.3	"
Acid	0.27	gal 60° Be H_2SO_4

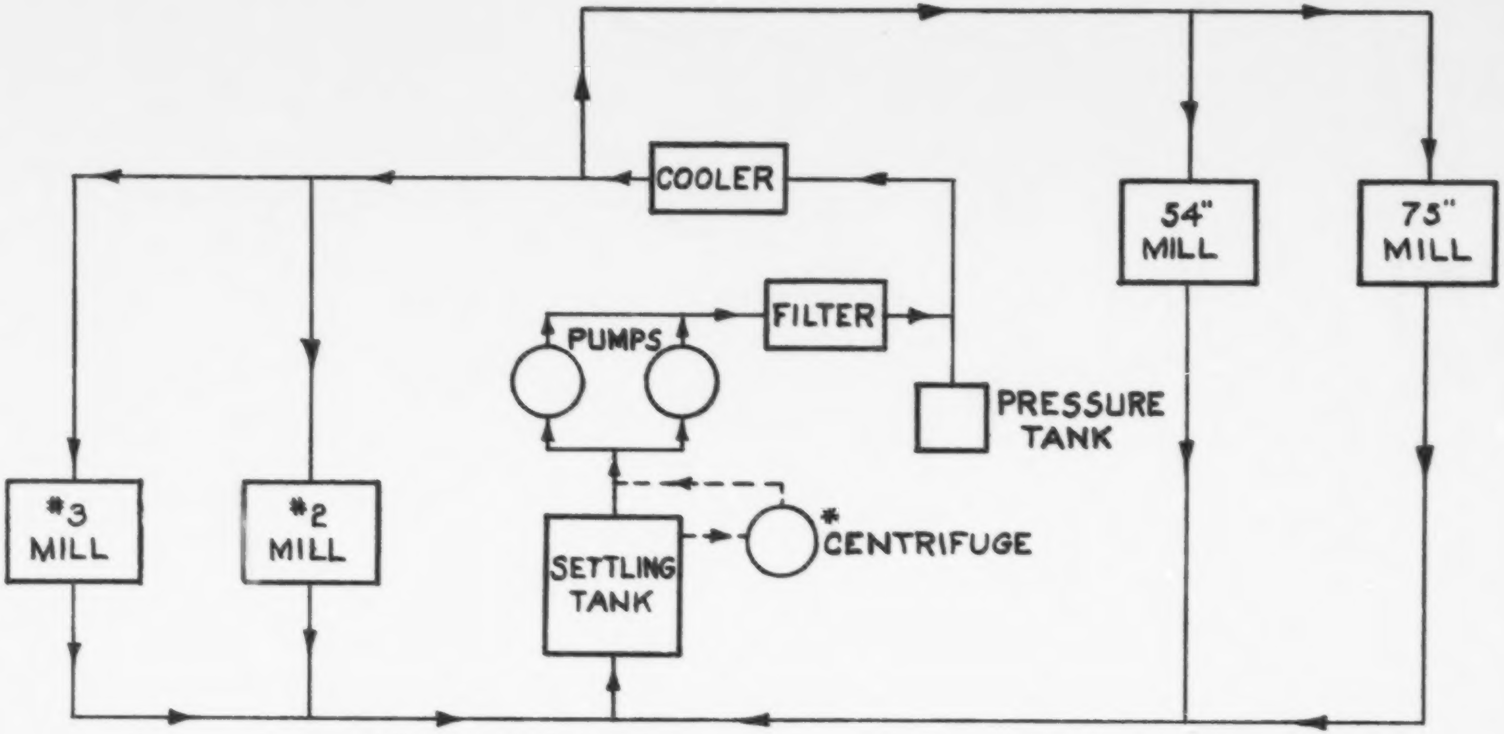
Oil Recovery System

Lubricating oil losses are kept to a minimum by means of nine oil recovery systems, five of which are in the cold mill, four in the hot mill. As all of these systems are practically identical, a discussion of one will serve for all.

The oil recovery system shown in Fig. C-7 is located in the cold mill and serves to lubricate the reduction gears and pinion stands of the four mills shown. In the system, used oil first passes through a settling tank for removal of settleable impurities.

The centrifuge in the system is operated intermittently - as required - in the cold mill oil systems, continuously in the hot mill systems. Unsatisfactory oil is automatically thrown out of the system by these centrifuges and passes into the sewer.

The settled oil is then pumped through a filter where smaller particles of dirt are removed. The pressure tank shown is a safety factor in the system. This tank maintains an air pressure of 50-60 pounds per square inch on the oil at this point. In case the pumps should break down, the air pressure would keep the oil in the system flowing for a minute or two, long enough to allow the mills to be shut down before extensive damage to the machinery was done. Following the filter, the oil is cooled indirectly in a water cooler, after which it goes to the points to be lubricated. Used oil is collected and the process begins anew. Sludge collected in the settling tank and centrifuges is discharged to the sewer.


COOLER
54" MILL
75" MILL
FILTER
PUMPS
PRESSURE TANK
*3 MILL
*2 MILL
SETTLING TANK
*CENTRIFUGE

* Intermittent Operation - Cold Mill
Continuous Operation - Hot Mill

FIGURE C7
TYPICAL OIL RECOVERY SYSTEM
BETHLEHEM STEEL CO.
LACKAWANNA, N.Y.
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DECEMBER, 1949

APPENDIX C

STRIP MILL DIVISION - HOT AND COLD MILL

Daily Analytical, Waste Quantity and Production Data

Strip Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949
Jan., 1950

TABLE C-4 - RAW WATER

Results of Analyses - p.p.m.

Date	Total solids		Suspended solids		Iron as Fe		Alkalinity M. O.	Oil	pH	5-day B.O.D.
	Total	Volatile	Total	Volatile	Total	Susp.				
12/13	292	158	51.5	12.0	9.23	7.64	95.6	5.1	7.4	11.2
12/14	330	140	44.5	17.0	7.11	6.60	97.0	11.6	7.6	14.0
12/15	348	134	38.0	9.0	5.62	5.16	100.4	8.8	7.8	15.4
12/16	268	114	40.5	21.5	5.82	5.28	99.0	0.7	7.8	11.9
12/19	294	128	40.5	12.0	6.55	5.88	97.0	6.8	7.4	10.8
12/20	284	124	44.5	15.5	5.76	4.72	94.4	4.1	7.6	8.7
Avg.	303	133	43.3	14.5	6.68	5.88	97.2	6.2	7.6	12.0

Strip Mill - Hot Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949
Jan., 1950

TABLE C-[illegible] - SCALE PIT

Results of Analyses - p.p.m.

Date	Total solids		Suspended solids		Total iron as Fe	Mill scale			Oil
	Total	Volatile	Total	Volatile		Tot. as Fe	Fe_2O_3-Fe	Fe_3O_4-Fe	
12/13	332	103	134	12	60.4	63.4	55.4	8.0	20.1
12/14	420	140	131	25	76.3	73.0	65.8	7.2	65.8*
12/15	488	146	183	16	55.4	77.9*	73.7*	4.2*	17.3
12/16	492	128	246	39	124.0	108.3	87.3	21.0	26.6
12/19	440	132	165	24	53.0	76.6	73.9	2.7	19.2
12/20	412	120	177	31	57.6	73.1	65.5	7.6	22.6
Avg.	431	129	173	25	84.5	78.9	69.6	9.3	21.2

* Not used in average.

Strip Mill - Hot Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949
Jan., 1950

TABLE C-6 - SCALE PIT
(Total discharge)

Constituents - Pounds/Day

Date	Flow M.G.D.	Total solids		Suspended solids		Iron as Fe		Oil	
		Total	Volatile	Total	Volatile	Total	Suspended	Pounds	Gallons**
12/13	12.9	35,700	11,600	14,400	1,290	6,890	6,810	2,160	285
12/14	13.3	46,500	15,500	14,500	2,760	8,450	8,090	7,290*	962*
12/15	12.4	50,400	15,100	18,900	1,650	5,720	6,050*	1,790	236
12/16	12.9	52,900	13,800	26,400	4,180	13,300	11,600	2,860	377
12/19	12.0	44,000	13,200	16,500	2,390	9,300	7,660	1,920	253
12/20	12.4	42,600	12,400	18,300	3,190	10,100	7,550	2,330	307
Avg.	12.7	45,400	13,600	18,200	2,580	8,900	8,300	2,210	292

* Not used in average.

** One gallon of oil equals 7.58 pound.

Strip Mill - Hot Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949
Jan., 1950

TABLE C-7 - SCALE PIT
(Discharged to sewer)

Constituents - Pounds/Day

Date	Flow M.G.D.	Total solids		Suspended solids		Iron as Fe		O i l	
		Total	Volatile	Total	Volatile	Total	Suspended	Pounds	Gallons**
12/13	3.4	9,400	3,050	3,800	340	1,690	1,760	570	75
12/14	3.4	11,500	4,000	3,700	710	2,140	2,060	1,860*	245*
12/15	3.4	13,000	4,100	5,200	450	1,550	2,200*	490	64
12/16	3.4	13,900	3,600	6,900	1,100	3,500	3,050	750	99
12/19	3.4	12,400	3,700	4,700	680	2,620	2,170	540	71
12/20	3.4	11,600	3,400	5,000	870	2,770	2,060	640	84
Avg.	3.4	12,200	3,600	4,900	700	2,380	2,220	600	79

* Not used in average.

** One gallon equals 7.58 pounds.

Strip Mill - Cold Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949
Jan., 1950

TABLE C-8 - TANDEM MILL SUMP

Results of analyses - p.p.m.

Date	5-day B.O.D.	Oil
12/13	71+*	228.9
12/14	70	143.2
12/15	53	111.8
12/16	74	203.1
12/19	155	163.2
12/20	64	191.7
Avg.	83	173.7

* Not used in average; oxygen depleted.

Constituents - Pounds/Day

To sewer

Date	Flow M.G.D.	5-day B.O.D.	Oil	
			Pounds	Gallons**
12/13	3.6	-	6,800	890
12/14	3.6	2,090	4,300	570
12/15	3.6	1,580	3,300	430
12/16	3.6	2,210	6,100	800
12/19	3.6	4,600	4,900	640
12/20	3.6	1,910	5,700	750
Avg.	3.6	2,500	5,200	680

** One gallon oil equals 7.6 pounds.

Strip Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949
Jan., 1950

TABLE C-9 - MAIN CUTFALL

Results of Analyses - p.p.m.

Date	Total solids		Susp. solids		Total iron as Fe	Mill scale			Alkalinity M. O.	Oil	pH	B.O.D.
	Total	Vol.	Total	Vol.		Total as Fe	Fe_2O_3 Fe	Fe_3O_4 Fe				
12/13	426	172	208.0	124.5	30.8	25.5	21.5	4.0	77.6	-	8.8	72+*
12/14	466	198	144	80.5	23.7	22.0	18.8	3.2	104.0	64.1	8.8	51
12/15	402	174	193.5	75.5	16.2	19.4	17.3	2.1	108.6	251.0*	8.9	38
12/16	546	176	152	55.5	90.4*	82.0*	73.5*	8.5*	98.6	115.0	8.9	42
12/19	448	184	143	68.0	31.7	28.8	25.9	2.9	102.2	90.0	8.9	44
12/20	436	156	135.5	65.5	37.6	30.8	28.6	2.2	98.4	70.6	8.9	42
Avg.	454	177	163	77.8	28.0	25.3	22.4	2.9	98.2	84.9	8.8-8.9	43

* Not used in average.

Strip Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949
Jan., 1950

TABLE C-10 - MAIN OUTFALL

Constituents
Pounds/Day

Date	Flow M.G.D.	Total Solids		Suspended Solids		Iron as Fe		Oil		5-Day BOD
		Total	Volatile	Total	Volatile	Total	Suspended	Pounds	Gallons**	Pounds
12/13	11.6	41,200	16,600	20,100	11,800	2,980	2,460	-	-	-
12/14	11.6	45,000	19,100	13,900	7,800	2,290	2,130	6,190	817	4,910
12/15	11.6	38,800	16,800	18,700	7,300	1,570	1,870	24,300*	3,210 *	3,660
12/16	11.6	52,800	27,000	15,700	5,400	8,740*	7,920*	11,100	1,460	4,040
12/19	11.6	43,300	17,800	13,800	6,600	3,060	2,780	8,700	1,150	4,240
12/20	11.6	42,100	15,100	13,000	6,400	3,630	2,980	6,820	900	4,040
Average	11.6	43,900	17,200	15,900	7,600	2,710	2,440	8,200	1,080	4,180

* Not used in average.
** One gallon oil = 7.58 pounds.

Strip Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949
Jan., 1950

TABLE C-11- CONTINUOUS PICKLER

Results of Analyses, p.p.m.

Date	Total solids		Suspended solids		Total iron as Fe	Acidity M O as CaCO$_3$	Acidity Mineral Acid as H_2SO_4
	Total	Volatile	Total	Volatile			
12/13	29,700	20,200	101.0	72.0	6,400	9,300	9,100
12/14	36,400	24,700	290	263	7,700	11,000	10,800
12/15	39,100	25,500	*1090	*962	9,000	11,000	10,800
12/16	37,400	25,700	131.0	97.5	8,100	12,000	11,800
12/19	25,000	17,400	106.5	80.0	5,100	8,800	8,600
12/20	14,700	11,000	96.9	80.5	2,510	6,200	6,100
Avg.	30,400	20,800	146	119	6,500	10,000	9,800

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To Sewer - Pounds per Day

Date	Flow M.G.D.	Total solids		Suspended solids		Total iron as Fe
		Total	Volatile	Total	Volatile	
12/13	0.65	160,000	109,000	544	368	34,500
12/14	0.65	196,000	133,000	1570	1,420	41,500
12/15	0.65	211,000	138,000	*5930	*5,180	48,600
12/16	0.65	203,000	138,000	710	525	43,700
12/19	0.65	135,000	94,000	580	431	27,500
12/20	0.65	79,000	59,000	525	434	13,500
Avg.	0.65	164,000	112,000	790	642	34,900

* Not used in average.

Strip Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec., 1949 Jan., 1950

TABLE C-12. BATCH PICKLER (MESTA)

Results of Analyses - p.p.m.

No. 1 Tank

Date	Total solids		Suspended solids		Total iron as Fe	Acidity M. O. as $CaCO_3$	Acidity Mineral Acid as H_2SO_4
	Total	Vol.	Total	Vol.			
12/13	391,000	238,000	260	144	108,000	77,000	75,500
12/14	396,000	264,000	70.0	38.0	88,000	113,000	111,000
12/15	420,000	256,000	360	246	115,000	69,000	67,000
12/16	227,000	151,000	146	81	52,000	56,000	55,000
12/17	335,000	197,000	248	122	94,000	51,000	50,000
12/19	440,000	299,000	228	134	102,000	147,000	144,000
12/20	285,000	176,000	588	240	79,000	61,000	60,000
12/21	264,000	63,000	210	88	69,000	47,000	46,000
Avg.	345,000	206,000	264	137	88,000	78,000	76,000

No. 2 Tank

12/17	236,000	149,000	164	84	58,400	64,000	63,000

No. 3 Tank

12/17	22,600	5,300	14,800	3,460	720	-	-

Strip Mill
Bethlehem Steel Co.
Lackawanna, N. Y.
Aug.-Sept., 1949
Dec.,1949 Jan.,1950

TABLE C-13 - BATCH PICKLER (MESTA)

Constituents - lbs. per dump

No. 1 Tank

Date	Flow gallons	Total solids		Suspended solids		Total iron as Fe
		Total	Vol.	Total	Vol.	
12/13	3,900	12,700	7,700	8.4	4.7	3,500
12/14	4,700	15,400	10,300	2.73	1.48	3,430
12/15	3,600	12,500	7,600	10.6	7.6	3,440
12/16	5,700	10,700	7,100	6.9	3.83	2,460
12/17	4,400	12,300	7,200	9.1	4.5	3,430
12/19	4,700	17,200	11,700	8.9	5.2	3,960
12/20	5,100	12,100	7,500	24.9	10.2	3,340
12/21	4,400	9,600	2,300	7.7	3.21	2,520
Average	4,600	12,600	7,700	9.9	5.1	3,260

No. 2 Tank

12/17	4,400	8,600	5,400	6.0	3.06	2,120

No. 3 Tank

12/17	4,700	680	206	580	135	28

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SECTION D

OUTFALL SEWER DISCHARGES AND WATER SUPPLY SYSTEM

October 16-24, 1951

by

Dean M. Taylor, Public Health Engineer

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SECTION D

OUTFALL SEWER DISCHARGES AND WATER SUPPLY SYSTEM

The outfall waste lines, discharging to Lake Erie and Buffalo Harbor were studied, during the period October 16 through October 24, 1951 for the purpose of estimating the amounts and concentrations of certain industrial waste constituents released from the plant. The water supplies were examined at the same time for the purpose of approximating the net quantities of these materials contributed by plant operations. The main features of the systems are shown in Figure D1.

Description of Systems

Water System

Sources

Water for cooling and process use is delivered to the plant from three pumping stations operated by Bethlehem Steel Company. These stations draw their supply from Buffalo Harbor and from the Ship Canal which connects to the harbor. Water for domestic and sanitary purposes is purchased from the Western New York Water Company which is supplied from Lake Erie.

The three pumping stations for industrial water are known as pumping stations numbers 1, 2 and 10. Station No.2 pumps approximately 60 mgd from Buffalo Harbor itself. Station No.1 pumps approximately 130 mgd from the east side of the plant ship canal at a point 3000 feet south of Buffalo Harbor. Station No.10 pumps approximately 20 mgd from the west side of the ship canal at a point 3100 feet south of Buffalo Harbor.

Approximately 2.8 mgd of treated Lake Erie Water are purchased from the Western New York Water Company whose treatment plant is located just south of the plant property near Lake Erie.

Uses

All of the water pumped from Buffalo Harbor and the ship canal is used for industrial purposes in the various divisions of the plant. Water from these sources is filtered and softened by the lime-soda process for boiler feed purposes. The water from the Western New York Water Company is used for sanitary purposes in all of the plant buildings.

Outfall Waste Line System

The process wastes are discharged to Buffalo Harbor and Lake Erie through three main sewer systems, namely, the south drain, Smokes Creek, and the drain north to Buffalo Harbor. Coke plant wastes are discharged into the plant ship canal but, due to the fact that more water is pumped from the ship canal than is discharged to it, flow is considered to be generally into the canal so that it would not be a waste outfall channel. The two industrial water supply pumping stations pump about 150 mgd from the ship canal while only about 23 mgd of wastes return to it. Therefore flow into the canal is at the rate of about 127 mgd. The volume of water contained in the canal is about 134 million gallons. The coke plant wastes discharged to the canal ultimately become part of the water supply pumped by pump station No. 1. This water is used in divisions of the plant which discharge wastes to the three main outlets mentioned above. Assuming this evidence of coke plant waste flow it may be stated that all waste constituents including those of coke plant wastes are discharged through the three outlets. Of course some reduction in quantities of biologically oxidizable and volatile constituents of coke plant wastes would be expected in the ship canal and subsequent channels. An objective of this

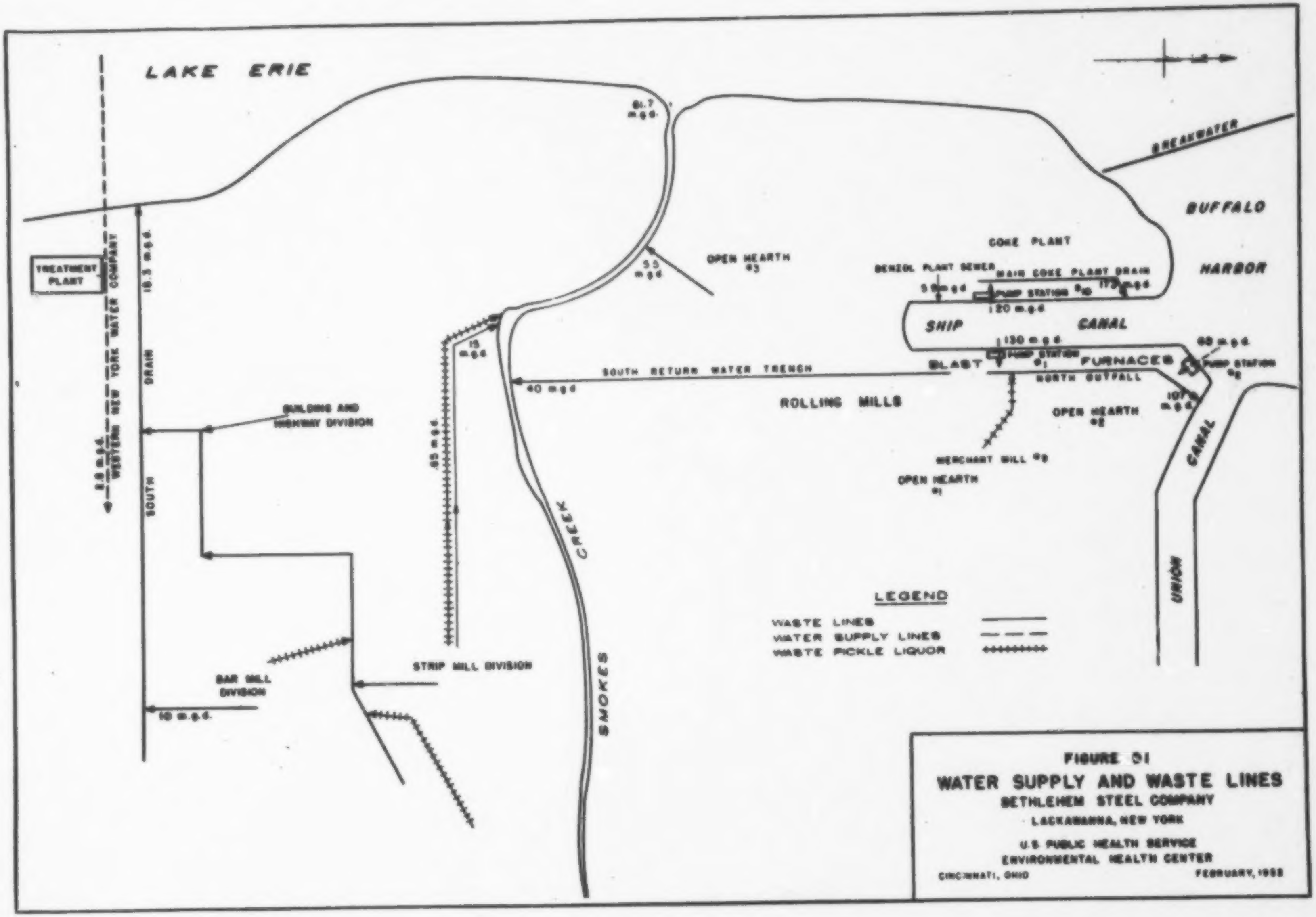
LAKE ERIE
61.7 m.g.d.
BREAKWATER
BUFFALO
HARBOR
COKE PLANT
BENZOL PLANT SEWER
MAIN COKE PLANT DRAIN
5.5 m.g.d.
PUMP STATION #10
173 m.g.d.
120 m.g.d.
SHIP
CANAL
130 m.g.d.
PUMP STATION #1
BLAST
FURNACES
90 m.g.d.
PUMP STATION #2
NORTH OUTFALL
107 m.g.d.
UNION
CANAL
OPEN HEARTH #2
MERCHANT MILL #9
OPEN HEARTH #1
ROLLING MILLS
SOUTH RETURN WATER TRENCH
40 m.g.d.
OPEN HEARTH #3
55 m.g.d.
15 m.g.d.
.05 m.g.d.
SMOKES
CREEK
TREATMENT PLANT
WESTERN NEW YORK WATER COMPANY
5.8 m.g.d.
18.3 m.g.d.
SOUTH
DRAIN
BUILDING AND HIGHWAY DIVISION
STRIP MILL DIVISION
BAR MILL DIVISION
10 m.g.d.
LEGEND
WASTE LINES
WATER SUPPLY LINES
WASTE PICKLE LIQUOR

FIGURE 51

WATER SUPPLY AND WASTE LINES
BETHLEHEM STEEL COMPANY
LACKAWANNA, NEW YORK

U.S. PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO FEBRUARY, 1953

study was to determine the extent of such action. Divisions of plant operations with discharge to the three outlets are tabulated for each outlet in sections following.

South Drain

The south drain originates on plant property and discharges directly into Lake Erie. The principal sources of wastes are:

(1) Building and highway division

(2) Bar mill division

  (a) Cooling and spraying water

  (b) Waste pickle liquor from the batch picklers

(3) Strip mill division

  (a) Cooling and spray water from hot mill runout table

  (b) Waste pickle liquor from Mesta (batch) pickler

  (c) Wastes from boiler house

Smokes Creek

Smokes Creek flows through Lackawanna before reaching Bethlehem Steel property and carries wastes from such sources as a railroad roundhouse, the effluent from the Lackawanna sewage treatment plant, and Spring Perch Company which manufactures automobile springs. The principal sources of wastes from Bethlehem Steel operational units are as follows:

(1) Strip mill division

  (a) All cooling and spray water in the hot mill with the exception of that for the runout tables

  (b) Waste pickle liquor from continuous picklers

  (c) Clean-up water

(2) South return water trench
  (a) 54 inch mill - slab for strip
  (b) 32 inch mill - (part of #1 mill) - finishes rails, billets, etc.
  (c) 35 and 21 inch mill - sheet piling and heavy structural shapes
  (d) 30 and 21 inch mill - billets
  (e) 14 inch mill - structural
  (f) 35" and 28" mills - structural
  (g) Pig machines
  (h) #3 Blowing engine house
  (i) Power house for mill #4
  (j) Gas washing water for blast furnace H - (not run through a settling unit)*

(3) Open hearth unit #3

(4) Structural yard.

* This is a temporary situation which resulted from the necessity of relocating the settling unit to make room for a new blast furnace.

Drain North to Buffalo Harbor

The drain north to Buffalo Harbor originates in the plant area and discharges into Union Ship Canal which is connected to Buffalo Harbor. The principal sources of wastes flowing into this drain are are as follows:

(1) Effluent from clarifiers serving 5 blast furnaces (A, B, C, F and G)

(2) 44 and 32 inch mills (mill #1) - blooming mill and rails

(3) 40 inch blooming mill - Mill #7

(4) 8 inch bar mill

(5) Open hearth #1

(6) Open hearth #2

(7) Foundry

(8) Power house #1 - air compressor cooling and barometric condenser

(9) Blowing engine house #2

(10) Blowing engine house #4

(11) Boiler house #5, power house #2, and boiler house #3

(12) Shops and storehouse

(13) Main office building.

Operations

Plant operations during the period of study of outfall sewer discharges differed in certain respects from those prevailing during the periods when blast furnace and rolling mill operations were started. Coke plant operations were the same as described in section B. The major difference concerned the handling of blast furnace gas washing wastes. In the period between the blast furnace waste study and the outfall sewer study, facilities for recovering settleable material from the gas washing and precipitator waters were installed. These facilities consist of four 2-compartment circular basins and a final tank for thickening the sludge drawn from the basins. The sludge is handled by storage in lagoons or filtered directly and fed to a sintering plant. During the period of the survey, one settling basin for blast furnace gas washing wastes was out of service. A new blast furnace was being constructed in a location which necessitated relocating the clarifier. Consequently, the untreated gas washing wastes from one blast furnace were discharged to Smokes Creek.

The process of clarifying and re-using scale pit effluents in the continuous strip mill, as described in Section C , had been discontinued. An increased supply of fresh water enabled use of fresh water entirely.

Production of pig iron and rolling operations were increased considerably from the time of waste surveys in these departments. Average daily production figures for the period of the outfall sewer survey are as follows:

Pig iron	7,504	tons
Coal carbonized	8,082	" (dry)
" "	8,400	" (wet)
Coke	5,904	" (dry)
Light oil	26,538	gallons
Ammonia liquor	139,972	"
Average flue temp.	2,462	°F
Slabs and blooms rolled	10,682	tons
Bars rolled	2,580	"
Structural shapes	1,785	"
Hot strip & plate	5,291	"
Cold strip & plate	3,779	"
Billets pickled	883	"
Plate pickled:		
Mesta pickler	739	"
Continuous pickler	3,581	"

Daily production figures for the period of the survey are given in Appendix D at the end of this section.

Survey Procedures

Sample Collection

Samples were collected by Public Health Service personnel from the following points at the time of the survey:

(1) Pump Station No. 1 - suction sump

(2) Pump Station No. 2 - suction sump

(3) Drain north to Buffalo Harbor - outlet to Union Canal

(4) Smokes Creek - outlet to Lake Erie

(5) South Drain - outlet to Lake Erie

(6) Main coke plant drain - outlet to ship canal.

The samples were collected at hourly intervals, over 8-hour periods from 8:00 A.M. to 4:00 P.M. Since the flows were fairly constant, equal portions were taken for compositing.

Separate samples were collected for the phenol and cyanide determinations. The phenol samples were preserved by adding approximately 4 gms. of copper sulfate per liter to carboys before sampling. The cyanide samples were preserved by adding pellets of sodium hydroxide to the carboys before sampling.

Flow Measurements

(1) Flow data for the pumping stations were obtained from plant officials.

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(2) The flows in Smokes Creek and the south drain were gaged with a current meter and daily flows were obtained by the use of float level recorders.

(3) Current meter gagings were taken in the drain north to Buffalo Harbor and the main coke plant drain.

Laboratory Procedures

The following determinations were made on the samples collected:

Phenols
Cyanides (CN)
Thiocyanates (NH_4SCN)
Total suspended solids
pH

In general, the procedures followed were as given in "Standard Methods for the Examination of Water and Sewage," 9th edition.(1) Special procedures for the phenols, cyanides and thiocyanates were used and will be found in the main appendix at the end of the report.

Explanation of Analyses

A brief explanation of the significance of the various laboratory determinations is given in the main appendix at the end of the report, and is intended to serve as an aid in the interpretation of the analytical results reported.

Results

The daily analytical results for the period of the survey are given in Appendix D at the end of this section of the report. A summarized presentation and discussion of the data follows.

Gross Outfall Sewer Discharges

The average gross concentrations of significant waste constituents discharged from the three plant outfalls are as follows:

	Drain North to Buffalo Harbor	Smokes Creek	South Drain
Phenols, ppm	0.13	0.18	0.12
Cyanides (CN), ppm	< .10	.17	< .10
Suspended solids, ppm	53.0	143.	60.6
pH range	7.0 - 7.6	3.8 - 6.0	3.0 - 5.5
Flow, mgd	107.	61.7	18.3

The concentration of thiocyanates was in every case below 4.0 ppm (as NH_4SCN), which is the lower limit of the quantitative accuracy of the method of determination employed. The lower limit for the cyanide determination was 0.10 ppm (as CN).

In considering the suspended solids in Smokes Creek, attention is called to the fact that the settling unit for the wastes of one blast furnace was temporarily out of operation during this survey. This untreated gas washing water was discharged to Smokes Creek.

The presence of acid pickling wastes is reflected in the low pH values shown. The intermittent nature of the pickling waste dumps probably accounts for the wide range of pH values of the composite samples.

The average daily quantities of significant waste constituents discharged from the plant are as follows:

Gross Wastes Discharged from Plant

	Drain North to Buffalo Harbor	Smokes Creek	South Drain	Total
Phenols, lbs	117	94	18.5	230
Cyanides (as CN), lbs	81	86	5.9	173
Suspended solids, lbs	47,100	72,900	9,030.	129,030
Flow, mgd	107	61.7	18.3	187

Water Supplies and Net Outfall Sewer Discharges

Several factors complicate the determination of net concentrations of constituents in the outfall sewers as discussed in subsequent paragraphs. Of first interest is the quality of the water supplies. The water pumped by stations Nos. 2 and 10 contains coke plant wastes. Pump station No. 10 supplies the coke plant. After use, this water returns to the ship canal from whence it was drawn. Therefore, station 10 does not enter the outfall waste discharge picture.

Pump stations 1 and 2 pump the water making up the discharge from the three outfall waste lines. The average concentrations of significant waste constituents in the water supplies are as follows:

	Pump Station No. 1	Pump Station No. 2
Phenols, ppm	0.15	0.047
Cyanides (CN), ppm	< .10	< .10
Suspended solids, ppm	15.6	8.1
pH range	7.3 - 7.8	7.4 - 7.8

The concentration of cyanide of 0.10 ppm (CN) is the lower limit of quantitative accuracy of the method of determination employed. The concentration of thiocyanate (as NH_4SCN) was in every case below 4.0 ppm, which is the lower limit of that determination.

The average daily quantities of significant waste constituents in the water supplies are as follows:

	Pump Station No. 1	Pump Station No. 2	Total
Phenols, lbs	162	23.2	185
Cyanides (as CN), lbs	0	0	0
Suspended solids, lbs	16,900	4,040	20,940
Flow, mgd	130	60	190

The origin of these constituents in the water drawn by station No. 1 is mainly the coke plant wastes, since the coke plant wastes are discharged to the ship canal from which pump station No. 1 draws its supply. The water entering the ship canal from Buffalo Harbor also contains a small concentration of the materials of interest. Though not sampled, it may be assumed that water entering the ship canal is of similar characteristics as that drawn by pump station 2. The source of phenol, etc., in this water is likely from the north outfall to Buffalo Harbor. In other words, recirculation of the wastes, to some extent, occurs, i.e., from ship canal through pump station, thence via north outfall to Buffalo Harbor, and thence in part to ship canal again. Reference is made to the diagram, Fig. D-2. Therefore the concentration of constituents entering the ship canal must be subtracted from the gross figures to arrive at net figures. The following results are those obtained for the net waste constituents discharged from the plant (based on 187 mgd, which is the total discharge of the outfall sewers).

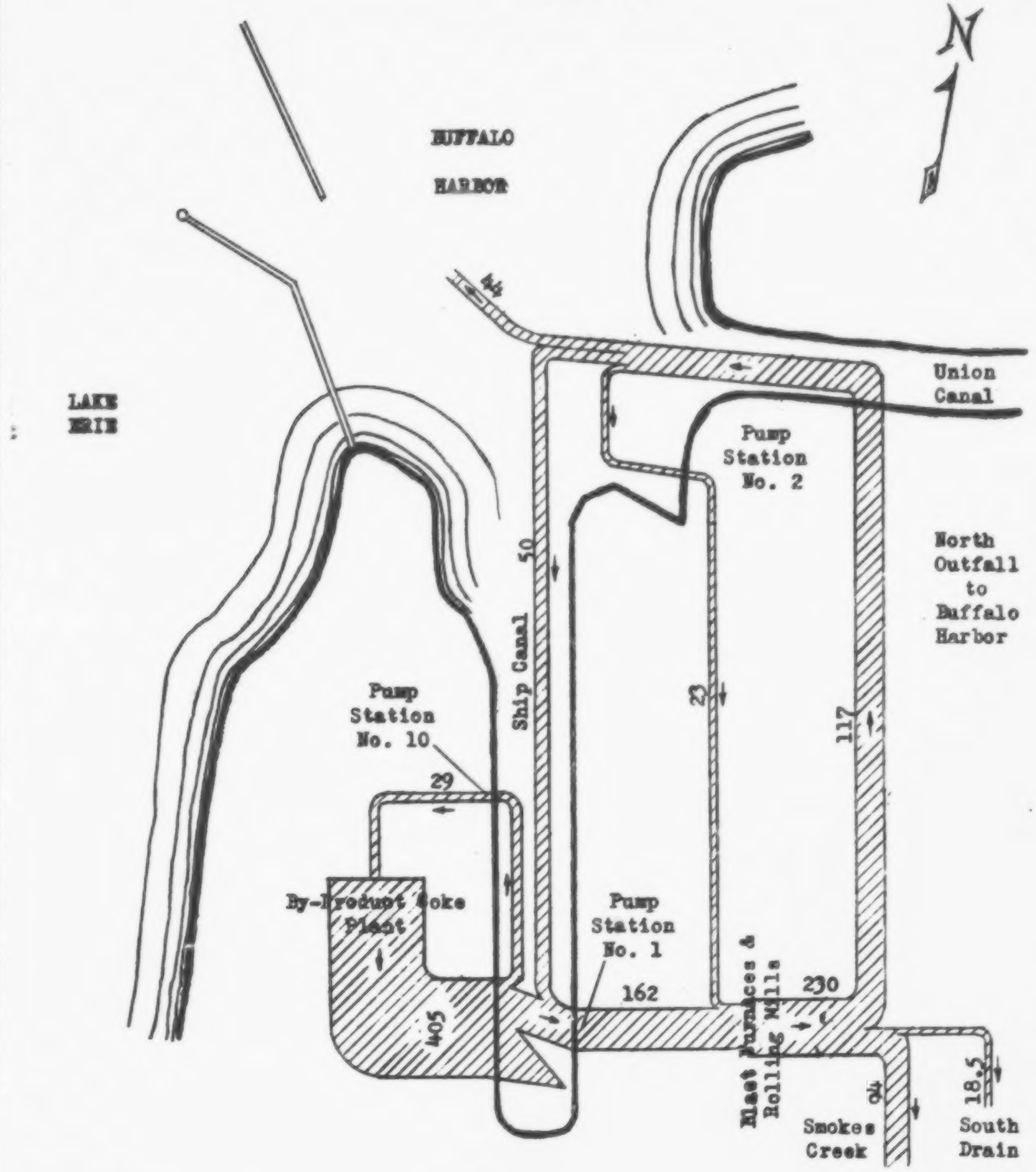
	Gross Quantities	Computed Quantity in Water Supply to Ship Canal & Station 2	Net Quantity in Outfall Sewers
Phenols, lbs	230	73.2	157
Cyanides (as CN), lbs	173	0	173
Suspended solids, lbs	129,000	12,600	116,400

The flow and quantity of pollutants in Smokes Creek upstream from the plant are comparatively negligible; for practical purposes, they may be disregarded.

Reduction of Waste Constituents in Ship Canal

Of particular interest is information obtained on reduction in phenol and cyanide content of coke plant wastes in the period between their discharge to ship canal and their being withdrawn as part of pump station No. 1 water supply. Assuming that the coke plant wastes do not escape to Buffalo Harbor from the ship canal, and neglecting the phenol content of waters entering the ship canal from Buffalo Harbor, the following reductions are indicated:

	Net Quantities in Coke Plant Wastes	Quantities Pumped by Station 1	Reduction in Ship Canal
Phenol, lbs	376	162	214
Cyanides (as CN), lbs	[illegible]	0	72


N
BUFFALO
HARBOR
LAKE
ERIE
44
Union
Canal
Pump
Station
No. 2
North
Outfall
to
Buffalo
Harbor
50
Ship Canal
23
117
Pump
Station
No. 10
29
By-Product Coke
Plant
Pump
Station
No. 1
162
230
405
Blast Furnaces &
Rolling Mills
46
18.5
Smokes
Creek
South
Drain

LEGEND:
Cross-hatched broad bands indicate, by width and figures, pounds of phenol in wastes and water supplies and their course from introduction to disposal.

Figure D 2
PHENOL DISTRIBUTION DIAGRAM
Bethlehem Steel Company
Lackawanna, N. Y.
Federal Security Agency
Public Health Service
Environmental Health Center
Cincinnati, Ohio November 1951

The phenol reduction is probably due to biological activity, and the cyanide reduction may be caused by volatilization and/or biological action.(2)(3) The direction of flow being exclusively into the canal is a matter of deduction. During storm periods the water level in Buffalo Harbor varies considerably, and water may flow both in and out of the ship canal.

APPENDIX D

OUTFALL SEWER DISCHARGES AND WATER SUPPLY SYSTEM

Daily Analytical and Waste Quantity Data

Bethlehem Steel Co.
Lackawanna, N. Y.

Table D-1 - Analytical Results
Concentrations and Quantities of Wastes

(Sheet 1 of 2)

Date 1951	Flow MGD	Phenols ppm	Phenols lbs	Cyanides ppm	Cyanides lbs	Thiocyanates (NH_4SCN) ppm	Thiocyanates (NH_4SCN) lbs	Suspended Solids ppm	Suspended Solids lbs	pH
		Water Supply - Pump Station No. 1								
Oct. 16	130	0.30	324	<0.10		<4.0		30.1	32,500	7.5
17	130	.10	108	< .10		<4.0		14.2	15,300	7.4
18	130	.20	216	< .10		<4.0		8.5	9,170	7.4
22	130	.10	108	< .10				6.5	7,010	7.3
23	130	.08	86	< .10				16.1	17,400	7.8
24	130	.12	130	< .10				18.5	20,000	7.7
Average		0.15	162	<0.10		<4.0		15.6	16,900	7.3-7.8
		Water Supply - Pump Station No. 2								
Oct. 16	60	0.10	49.8	<0.10		<4.0		9.9	4,930	7.7
17	60	.02	10.0	< .10		<4.0		6.8	3,390	7.8
18	60	.08	39.8	< .10		<4.0		7.4	3,690	7.5
22	60	.02	10.0	< .10				5.4	2,690	7.4
23	60	< .01		< .10				9.8	4,880	7.8
24	60	.06	29.9	< .10				9.3	4,630	7.8
Average		0.047	23.2	<0.10		<4.0		8.1	4,035	7.4-7.8
		Drain North to Buffalo Harbor								
Oct. 16	107	0.20	178	0.26	231	<4.0		47	41,700	7.3
17	107	.09	80	< .10		<4.0		62.5	55,500	7.0
18	107	.10	88.8	< .10		<4.0		35.1	31,200	7.4
22	107	.10	88.8	< .10				40.0	35,500	7.5
23	107	.10	88.8	.16	142			86.6	76,900	7.6
24	107	.20	178	.13	116			47.0	41,700	7.3
Average	107	0.13	117	0.09	81	<4.0		53.0	47,100	7.0-7.6
		Smokes Creek								
Oct. 16	64	0.30	159			<4.0		140	74,400	4.8
17	64	.15	79.7	0.19	101	<4.0		124	65,900	5.9
18	61.6	.20	102	< .10		<4.0		90	46,000	3.8
22	58.0	.10	48.3	.26	125			216	104,000	6.0
23	61.0	.16	81	.23	116			146	74,400	5.5
Average	61.7	0.18	94.0	0.17	86	<4.0		143	72,900	3.8-6.0

Bethlehem Steel Co.
Lackawanna, N. Y.

Table D-1, Continued - Analytical Results
Concentrations and Quantities of Wastes

(Sheet 2 of 2)

Date 1951	Flow MGD	Phenols		Cyanides		Thiocyanates (NH_4SCN)		Suspended Solids		pH
		ppm	lbs	ppm	lbs	ppm	lbs	ppm	lbs	
South Drain										
Oct. 16	19.7	0.08	13.1	<0.10		<4.0		30.4	4,970	3.1
17	18.9	.20	31.4	< .10		<4.0		18.6	2,920	3.2
18	18.9	.20	31.4	< .10		<4.0				5.5
22	16.3	.08	10.8	< .10				53.8	7,280	3.0
23	17.5	.08	11.6	< .10				104	15,100	5.1
24	18.6	.08	12.4	.23	35.5			96.3	14,900	5.2
Average	18.3	0.12	18.5	<0.10	5.9	<4.0		60.6	9,030	3.0-5.5
Coke Plant Drain										
Oct. 16	17.2	3.5	500	0.39	55.7	<4.0		119	17,000	7.5
17	17.2	2.5	357	.33	47.1	<4.0		41.4	5,910	7.6
18	17.2	2.0	286	.34	48.5	<4.0		59.0	8,420	7.2
22	17.2	1.5	214	.36	51.4			43.0	6,140	7.5
23	17.2	1.75	250	.26	37.1			66.8	9,540	7.8
24	17.2	1.75	250	.29	41.4			83.0	11,800	7.9
Average	17.2	2.17	309	0.33	46.9	<4.0		68.7	9,801	7.2-7.9

Bethlehem Steel Company
Lackawanna, N. Y.

Table D-2 - Production Data

	Oct.16	Oct.17	Oct.18	Oct.22	Oct.23	Oct.24	Average
Tons pig iron produced	6,788	7,125	7,065	7,122	7,381	7,544	7,504
" coal carbonized (dry)	7,802	8,074	8,377	8,086	8,069	8,083	8,082
" " " (wet)	8,258	8,547	7,926	8,573	8,521	8,573	8,400
" coke produced (dry)	5,714	5,913	5,831	5,992	5,973	6,000	5,904
Gallons light oil	27,247	26,100	27,245	25,774	27,479	25,382	26,538
" ammonia liquor	148,400	135,504	146,600	144,000	138,128	127,200	139,972
Average flue temperature(°F) of coking ovens	2,459	2,458	2,472	2,454	2,471	2,460	2,462
Tons billets pickled	815	1,017	931	540	1,110	885	883
" plate pickled:							
Mesta	944	946	779		796	969	739
Continuous	4,684	3,230	3,538	3,262	3,910	2,863	3,581

Acknowledgment

It is desired to express deep appreciation to the Bethlehem Steel Company for affording this opportunity of studying wastes from an integrated steel mill. In particular, the assistance, advice and forbearance of many of the staff of the Lackawanna Plant merit sincere thanks. Mr. P. F. Kinyoun, Combustion Engineer, Mr. R. W. Pugh, Superintendent, By-Product Coke Plant, and Mr. T. Tooke, Engineer, Continuous Strip Mill Division, gave freely of their time and advice in planning and conducting the various surveys. Special acknowledgment is due Mr. J. A. Joseph of Mr. Kinyoun's staff, whose wide knowledge of this plant and its operation were invaluable to the Public Health Service staff. His daily interest and contact with the survey, his advice and understanding, and his most helpful co-operation, greatly facilitated this study.

Mention should also be made of the willing help, both material and in explaining the various operations, given by all of the Bethlehem personnel contacted.

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MODIFIED ANALYTICAL PROCEDURES

Phenols

Preliminary Screening Procedure

Add 2 ml of 10% copper sulfate solution to 250 ml of sample and bring the pH of the mixture below 4.0 by the addition of 10% phosphoric acid solution. Put the mixture in an all-glass distillation apparatus and distill over approximately 200 ml. Halt the distillation and allow the distilling flask to cool until boiling ceases. Add 50 ml distilled water to the distilling flask and resume the distillation until a total of 250 ml plus the volume of reagents added has been distilled over.

Acidify the distillate with 1 ml of 10% phosphoric acid solution and add 5 ml of 10% copper sulfate solution. Transfer the mixture to a separatory funnel containing 75 g fine-grained C.P. sodium chloride. Make three serial extractions with C.P. chloroform. On the first extraction, shake the mixture until the salt has been completely dissolved. Use 50 ml of chloroform per extraction. Collect the chloroform extracts, discarding the aqueous phase after the third extraction. Combine the chloroform extracts. Extract the chloroform twice with 75 ml portions of 0.1 N sodium hydroxide, discarding the extracted chloroform. Combine the alkaline extracts and make up to 250 ml with distilled water.

Estimation of Phenols

Bromination Procedure - for phenol concentrations over 10. ppm.

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Take an aliquot portion of the sodium hydroxide extract obtained in the screening procedure (the portion so taken that it contains about 0.05 g phenols) and dilute to exactly 200 ml. Place the sample in a 500 ml glass-stoppered Erlenmeyer flask and add 50 ml of bromate-bromide solution (2.784 g $KBrO_3$ ⨍ 10 g KBr diluted to one liter with distilled water), followed by 5 ml of concentrated hydrochloric acid. Place in hot water bath at 25°C for one hour and add 2 g potassium iodide. After 5 minutes, titrate the liberated iodine with 0.1 N thiosulfate solution in the presence of starch indicator.

Run a blank in the same manner as the sample, using distilled water.

Calculation of Phenol

1 ml 0.1 N thiosulfate solution = 0.001567 g phenol

$$\text{ppm phenol} = \frac{(\text{ml thiosulfate for blank} - \text{ml for sample})\ 1.567 \times 1000}{\text{ml of sample}}$$

Gibbs Procedure - for phenol concentrations less than 10 ppm. Use the method in Standard Methods.(1) The dye produced by the Gibbs reaction was extracted with 5 ml n-butyl alcohol from the aqueous phase and visual color comparison made in the top of the Nessler tubes. The standard phenol solution was made from C.P. phenol alone, rather than a mixture of phenol and o-cresol.

Cyanides

Procedure

Make a 200 ml portion of the sample alkaline to phenolphthalein with 10% sodium hydroxide solution, using a spot plate and cautiously adding the sodium hydroxide to avoid gross excesses. Add an excess of dry lead carbonate and mix well. Filter, using a fluted filter paper and save filtrate. Take a 105 ml portion of the filtrate or, if appreciable quantities of sodium hydroxide have been required, take a sample which will correspond to 100 ml of the original portion. Add 1.5% tartaric acid solution until sample is acid to methyl orange. Add an additional one ml of tartaric acid solution and dilute to 500 ml. Using an all-glass distillation apparatus, distill over 50 ml, catching the distillate in a 100 ml graduate containing 50 ml of 2% sodium hydroxide. The delivery tube from the condenser should extend well below the surface of the liquid in the receiving vessel. Add 8-16 drops of p-dimethylaminobenzalrhodamine indicator (0.02% in acetone) per 100 ml of sample and titrate with 0.001 N $AgNO_3$ until yellow color turns to light salmon pink. Run a blank in parallel with the sample in order to determine the sensitivity of the indicator (the same amount of indicator should be used for all titrations, depending upon the color perception of the operator).

Calculation:

$$1 \text{ ml } 0.001 \text{ N } AgNO_3 = 0.052 \text{ mg CN}$$

$$\text{ppm Cyanides (CN)} = \frac{(\text{ml } 0.001 \text{ N } AgNO_3 - \text{ml for blk.})\ 0.052 \times 1000}{\text{ml of sample}}$$

Reference - Ryan, J. A., and Culshaw, G. W. "Use of p-dimethylaminobenzalrhodamine as indicator for the volumetric determination of cyanide." Analyst 69, p. 370-371 (1944).

Thiocyanates

A portion of sample is shaken up with an excess of dry lead carbonate in a flask until all the sulfide has been removed. Filter, take 100 ml of the filtrate, and acidify with dilute sulfuric acid. The acid should be added gradually to avoid the violent effervescence due to the ammonium carbonate in solution. Sodium bisulfite solution is added, followed by cupric sulfate in excess. The mixture is than raised just to a boil, and left to stand 3-4 hours. The cuprous thiocyanate precipitate, which is frequently of a dark or black color due to a small quantity of copper sulfide, is filtered and thoroughly washed. The washed precipitate is then boiled with an excess of sodium hydroxide and again filtered and washed. The filtrate, when cold, is acidified with dilute nitric acid, a few drops of ferric nitrate or sulfate solution added, and titrated with 0.1 N silver nitrate solution until the red color of the ferric thiocyanate just disappears.

$$1 \text{ ml } 0.1 \text{ N } AgNO_3 \simeq 0.00761 \text{ g } NH_4SCN$$

Reference - Williams, H.E. "Cyanogen Compounds - Their Chemistry, Detection and Estimation." Edward Arnold & Co., London. Second Edition, pp. 397-398.

Total Iron

Reagents and Solutions

1. Potassium dichromate #1. Dissolve 4.3907 gms $K_2Cr_2O_7$ in 1 liter with distilled water. One ml $\simeq$ 5 mg as Fe.

2. Potassium dichromate #2. Dilute 200 ml of $K_2Cr_2O_7$ #1 to 1 liter with distilled water. One ml $\equiv$ 1 mg as Fe.

3. Stannous chloride #1. Dissolve 50 gms of $SnCl_2$ in 100 ml. of concentrated HCl and dilute to 1 liter with distilled water.

4. Stannous chloride #2. Dilute 200 ml of $SnCl_2$ #1 to 1 liter with distilled water.

5. Hydrochloric acid, concentrated.

6. Hydrochloric acid, 1 : 1 (6 normal).

7. Nitric acid, concentrated.

8. Perchloric acid, 60 or 72 per cent.

9. Sulfuric-Phosphoric acid solution. Mix two parts of 1 : 1 sulfuric acid with one part of 85 per cent phosphoric acid.

10. Sodium diphenylaminesulfonate indicator: Dissolve 0.32 gm of barium diphenylamine indicator in 100 ml of distilled water and add 0.5 gm of Na_2SO_4 to precipitate barium. Settle out the precipitate and decant the clear solution.

11. Saturated mercuric chloride solution.

Procedure for Low Iron Concentrations

1. Take a 100 or 200 ml portion of sample.
2. Add 2 ml concentrated HCl and 0.3 ml of $SnCl_2$ #1.

3. Evaporate to about 10 ml in volume, add 2 ml of concentrated HNO_3 and boil for 3-5 minutes.

4. Add 2 ml of $HClO_4$, boil until fumes of $HClO_4$ appear and then bake dry on hot plate, using low heat.

5. Cool slightly and add 5 ml of 1 : 1 HCl, adding the first few mls slowly and with caution.

6. Bring to boil to dissolve iron residue, add $SnCl_2$ #1 until light yellow color of $FeCl_3$ is evident.

7. Add $SnCl_2$ #2 dropwise until solution is just colorless. Cool under tap immediately. No excess of $SnCl_2$ should be present and solution should remain colorless.

8. Add 5 ml of $HgCl_2$ solution in one shot and allow to stand for 3 minutes. (If precipitate turns dark, procedure must be repeated).

9. Add 5.0 ml of H_2SO_4 - H_3PO_4 solution, cool under tap and dilute to 100 ml with distilled water.

10. Add 6 drops of diphenylamine indicator and titrate with $K_2Cr_2O_7$ #2. The end point is a blue-purple color. Subtract the amount required for the indicator. This may be done by reading the burette as the end point is approached, taking the reading just prior to the purple color. (Amount required for indicator is usually 1 drop or 0.05 ml).

Procedure for High Iron Concentration

1. Take a 50 ml portion of sample.

2. Add 4.0 ml of concentrated HCl and 0.3 ml of $SnCl_2$.

3. Evaporate to about 10 ml volume, add 4 ml of concentrated HNO_3 and boil for 3-5 minutes.

4. Add 2 ml of $HClO_4$, boil until fumes of $HClO_4$ appear and then bake dry.

5. Cool slightly and add 10 ml of 1 : 1 HCl, adding first few mls slowly and with caution.

6. Bring to boil to dissolve iron residue, add $SnCl_2$ #1 until light yellow color of $FeCl_3$ is evident.

7. Add $SnCl_2$ #2 dropwise until solution is just colorless, etc. (See No. 7. on previous page).

8. Add 5 ml of $HgCl_2$ solution in one shot and allow to stand for 3 minutes. (If precipitate turns dark, procedure must be repeated).

9. Add 10 ml of H_2SO_4 - H_3PO_4 acid, cool under tap and dilute to 250 ml with distilled water.

10. Add 12 drops of diphenylamine indicator and titrate with $K_2Cr_2O_7$ #2. Observe same precautions in titrating as in procedure for low iron concentrations.

Precautions

In both procedures, if an excess of $SnCl_2$ was added under step 7, boil until slight yellow appears and repeat decolorization and cooling, using $SnCl_2$ #2. Any excess of $SnCl_2$ will cause the precipitation of free mercury, dark precipitate, referred to in step 8.

Calculation

$$\text{ml of } K_2Cr_2O_7 \times \text{mg Fe/ml of } K_2Cr_2O_7 \times \frac{1000}{\text{ml sample}} = \text{ppm as Fe}$$

Note

Where mill scale was present, as in analysis of the samples obtained from the scale pit of the strip mill, step 3 in the above procedures was modified as follows:

3. Evaporate to dryness on the steam bath, dry in the oven at 103°C for 1-2 hours, and ignite in the muffle furnace at 550°C for one and one-half hours.

Mill Scale Analysis

Materials

1. Unweighed Gooch crucibles containing acid-washed asbestos mats.
2. Rubber stopper fitted with Bunsen valve.
3. Erlenmeyer flasks, 300 ml and 500 ml, to receive Bunsen valve.

Reagents

1. Reagents as in determination of total iron.
2. $NaHCO_3$ C.P.

Procedure

1. Take two 500 ml. portions, or suitable quantity, of sample, and filter each portion through a separate Gooch crucible.

2. Wash the residue in the Gooch crucibles with three successive washings, using 2 ml of distilled water each time.

3. Transfer the residue and asbestos mat from each Gooch crucible to an ignition crucible and cover one crucible to prevent oxidation, after drying at 103°C.

4. Ignite both crucibles one and one-half hours at 550°C, and cool

FeO Determination

5. Transfer covered sample to 300 ml Erlenmeyer, rinsing all particles carefully into flask and bring volume to 100 ml with distilled water.

6. Add 0.4 gm of $NaHCO_3$ or 0.5 gm Na_2CO_3 and 20 ml of 1 : 1 HCl and stopper immediately with Bunsen valve.

7. Heat until iron is dissolved, and cool under tap.

8. Proceed as in normal iron determination for low concentrations, part 9. Calculate to ppm Fe, which represents FeO.

Total Iron

9. Transfer residue from second crucible to 300 ml Erlenmeyer, bring into solution with HCl and $SnCl_2$ and proceed as in iron determination for blast furnace samples. Calculate to ppm Fe, which represents total iron.

Calculation

Mill scale = FeO as Fe x 3 or iron as Fe_3O_4 in sample.

Subtract from total for Fe_2O_3 iron.

Determine the FeO and total iron as above in representative mill scale samples to replace the theoretical factor used above if warranted.

Determination of Oil

Sampling Procedure

1. Sampling vessels.

   (1) The sampling vessel shall be a clean glass-stoppered vessel of known capacity - approximately one liter.

   (1-a) If it is desired to examine composite samples, vessels shall consist of clean glass-stoppered vessels of known capacity. The total volume held by the number of portions composited shall be approximately one liter.

2. Extraction mixture - 50% C.P., fat-free carbon tetrachloride by volume; 50% C.P., A.C.S. diethyl ether by volume.

3. Sample portions shall consist of a full bottle, or a vessel filled up to a prefixed calibration mark. The entire contents of a sample vessel must be used.

Procedure

Determine the pH of the sample. If compositing is being practiced, the subsamples should be composited in a 2-liter separatory funnel and mixed before the pH is checked. If the pH is above 6.0, add 1 ml. portions of 85% hydrochloric acid until the pH falls below 6. Then add a further 10 ml portion of 85% hydrochloric acid. If the pH of the sample is initially below 6.0, add 10 ml of 85% hydrochloric acid without preliminary adjustment of pH. Rinse the sample container, or containers, with an 80 ml portion of the extraction mixture. After the extraction mixture has been used to rinse the sample containers, transfer it to the extraction flask and shake vigorously with the sample for two minutes. The sample is allowed to stand long enough for the solvent layer to separate. The lower solvent layer is then separated. Rinse the sample container, or containers, with a further 60 ml portion of solvent. Add the solvent to the sample in the separatory funnel and shake for two minutes. Separate the solvent layer and add it to the solvent already collected from the first extraction. Make a third rinsing and extraction, using a further 60 ml portion and the same technique as was used for the second extraction.

Put the combined extract portions into the separatory funnel with one liter of distilled water and shake thoroughly for two minutes. Separate the extract, and wash the distilled water with 30 ml of extraction mixture. Add the wash solvent to the separated extract. Filter the combined extract portions through a fat-free filter paper. Wash the paper three times with 5 ml portions of solvent, combining the filtrate and the wash solvent. Evaporate the combined extract on a steam bath under a hood in a weighed dish. When the solvent has been evaporated, transfer the dish to an oven maintained at 103°C. Dry for 30 minutes; cool the dish in a desiccator. Reweigh the dish.

Calculation

$$\frac{\text{Weight of oil in mg}}{\text{Vol. of sample in liters}} = \text{ppm "oil"}$$

Note: With a few samples, the solvent will not separate completely from the sample, but forms a heavy solvent-in-water emulsion which will sink to the bottom of the separatory funnel. With such samples, the emulsions should be separated. When the emulsions are all collected, they may usually be broken by shaking with 500 ml of 1% hydrochloric acid solution in a separatory funnel. In rare cases, several washes may be required. Regardless of whether one or two rinses is required, the wash water should be given one clean-up extraction with 30 ml of solvent after the main body of the solvent has been separated. The wash solvent is separated and added to the main body of the solvent. It is then washed with water, etc.

Significance of Laboratory Analyses

Phenols

The phenol results, as reported, represent the gross quantity of phenolic constituents such as phenols, cresols, etc. These substances are found in variable proportions and amounts in certain types of industrial wastes. They may result, as in by-product coke and gas plant wastes, from the pyrolysis of coal.

Phenols may cause tastes and odors in water supplies. Concentrations of as little as 0.002 to 0.005 ppm phenols may produce chlorophenol (medicinal) tastes and odors in the presence of chlorine in water. A concentration of 0.1 ppm of phenol alone will impart the characteristic taste and odor of phenol to water. Phenolic compounds are toxic to aquatic life, with lethal limits being dependent on such factors as concentration, time of exposure, and the characteristics of the water. The minimum concentration of phenol reported as being toxic to fish is 0.4 ppm. Fish exposed to phenolic compounds in water will acquire the tastes and odors of these compounds.

Cyanides

The cyanide results are reported in terms of CN and represent the so-called "free" cyanides which include the normal salts of HCN as well as any HCN present. Cyanides are very toxic, and concentrations as low as 0.05 to 0.1 have been reported as killing fish. Minimum lethal concentrations vary for different species of aquatic life and are influenced by such factors as time of exposure, the characteristics of the water, and temperature.

Thiocyanates

The thiocyanate results are reported in terms of NH_4SCN and represent the salts of thiocyanic acid for the most part because thiocyanic acid is very unstable. Thiocyanates are of interest when considering wastes from the carbonization of coal. Cyanides are readily converted to thiocyanates in the presence of sulfur and sulfides, and these cyanates are more stable compounds than the cyanides. Thiocyanates themselves have been reported as being relatively nontoxic to aquatic life. They are capable, however, of combining with chlorine to form cyanogen chloride which has been reported as being lethal to fish in a concentration of 0.1 ppm.

Ammonia

The ammonia results are reported in terms of free, fixed and total ammonia nitrogen (N). The free ammonia nitrogen represents ammonia in solution and is typical of the ammonia removed in the free leg of an ammonia still. The fixed ammonia nitrogen was determined by making the sample, from which the free ammonia was distilled, alkaline to phenolphthalein and distilling off the ammonia. It corresponds to the ammonia removed in the fixed leg of an ammonia still. The total ammonia nitrogen represents the sum of the free and fixed ammonia nitrogen.

Solutions of ammonia, or ammonium hydroxide, and also of ammonium salts, can be very toxic to fish even when the pH is not very high (that is, below pH 9). The toxicity of these solutions evidently is dependent largely on the concentration of the undissociated base (NH_4OH), which increases with the pH value, as well as with the over-all ammonium content. A concentration of the nonionic free ammonia, or ammonium base of 1.2 to 3 ppm (as NH_3) has been reported to be quite rapidly and uniformly toxic to a relatively hardy species in solutions of varying pH and ammonium ion content. Several investigators have reported that the addition of only 2 to 7 ppm of ammonia (as NH_3) to certain waters proved lethal to some fish.

Oils

The oil results were obtained by extracting the samples with a 1 : 1 mixture (by volume) of diethyl ether and carbon tetrachloride. These results represent all of the materials which are soluble in these organic solvents, and not just the true oils as such.

Oily materials are objectionable from the standpoint of stream pollution because they are unsightly, damaging to wildlife and aquatic life, detrimental to recreational facilities, and interfere with treatment processes for public and industrial water supplies. Oily films on the surfaces of lakes and streams interfere with the normal reaeration of the water and may be difficult to remove. Certain sludges may contain oily materials which may be toxic to bottom fauna and flora.

Biochemical Oxygen Demand (B. O. D.)

The biochemical oxygen demand of sewage, polluted waters, or industrial wastes, is the oxygen (in ppm) required during stabilization of the decomposable organic matter by aerobic bacterial action. The rate of oxygen demand is dependent on both time and temperature, and consequently the standard conditions of 5 days' incubation at 20°C are usually used for the test. Approximately 68 per cent of the oxygen demand of the carbonaceous material present in normal domestic sewage is satisfied under the conditions of 5 days' incubation at 20°C. The oxygen demand rates of industrial wastes, however, may or may not follow the typical oxidation curve for domestic sewage.

It would be necessary to incubate a particular sample of waste for such a period of time that no more oxygen demand was exerted, in order to determine the total B.O.D.

High B.O.D. values are objectionable from a stream pollution standpoint because they reduce the oxygen resources of the streams, adversely affecting the aquatic life. If the oxygen content is depleted, anaerobic conditions develop and the water is rendered undesirable for supply and recreational purposes.

Solids

Solids analyses include those for total solids, suspended solids, and the volatile constituents of each. Suspended solids are insoluble solids which either float on the surface of the liquid, remain in suspension, or settle out on standing. They are determined by filtering samples through asbestos mats in Gooch crucibles. Total solids consist of all the solids in a sample and include both suspended and dissolved solids. Volatile solids are those solids in the sample which are lost on ignition, in a muffle furnace, of the total and suspended solids at 600°C.

Large quantities of suspended solids are objectionable from the standpoint of stream pollution because they settle out and cause silting and sludge banks. Suspended solids are also objectionable in water supplies used for domestic and industrial purposes. The volatile solids results are obtained by an empirical method but they are intended to indicate the organic material content of the solids.

Iron

Determinations were made for both total and dissolved iron and the results are expressed as Fe. Dissolved iron analyses were made on samples, which had been filtered through asbestos mats in Gooch crucibles, for the purpose of determining whether or not any of the iron in the samples was in solution. The iron analyses made during See page 127 this survey indicated that all of the iron was insoluble, in the form of iron oxides, ores and/or metallic iron.

Iron is objectionable in water supplies used for both domestic and industrial purposes. The Public Health Service Standards for Drinking Water state that the iron and manganese together should not exceed 0.3 ppm. Iron and iron compounds may cause bad tastes and odors in drinking water and will stain plumbing fixtures and laundered materials. Many manufacturing processes require the absence or low concentration of iron.

pH

The symbol "pH" denotes the negative logarithm of the hydrogen-ion ? normality. The pH value indicates the relative acidity or alkalinity of a solution, being lower with higher degrees of acidity

pH data are helpful in measuring the effects of acid and alkaline wastes on natural surface waters. Acids causing pH values below 4.0 and alkalies causing pH values above 10.0 are undesirable and hazardous for fish life in waters which are not naturally so acid or alkaline. pH is also an important factor when considering treatment for domestic and industrial water supplies.

Alkalinity

The alkalinity of a water or waste is usually caused by the presence of carbonates, bicarbonates, hydroxides, and less frequently by borates, silicates, and phosphates. The amount of alkalinity is determined by titration with a standard solution of strong acid to certain equivalence points as given by indicator solutions. Phenolphthalein and methyl orange, or their equivalents, are used to obtain these equivalence points. Alkalinity results are expressed as parts per million of calcium carbonate ($CaCO_3$).

Temperature

The temperature of a natural body of water determines, to a large extent, the ability of that water to assimilate oxygen-demanding wastes. The higher the temperature, the lower the quantity of dissolved oxygen required to saturate the water. Heat added in steel mill cooling processes may markedly affect a stream's ability to relieve pollutional loads, especially under low-flow conditions.